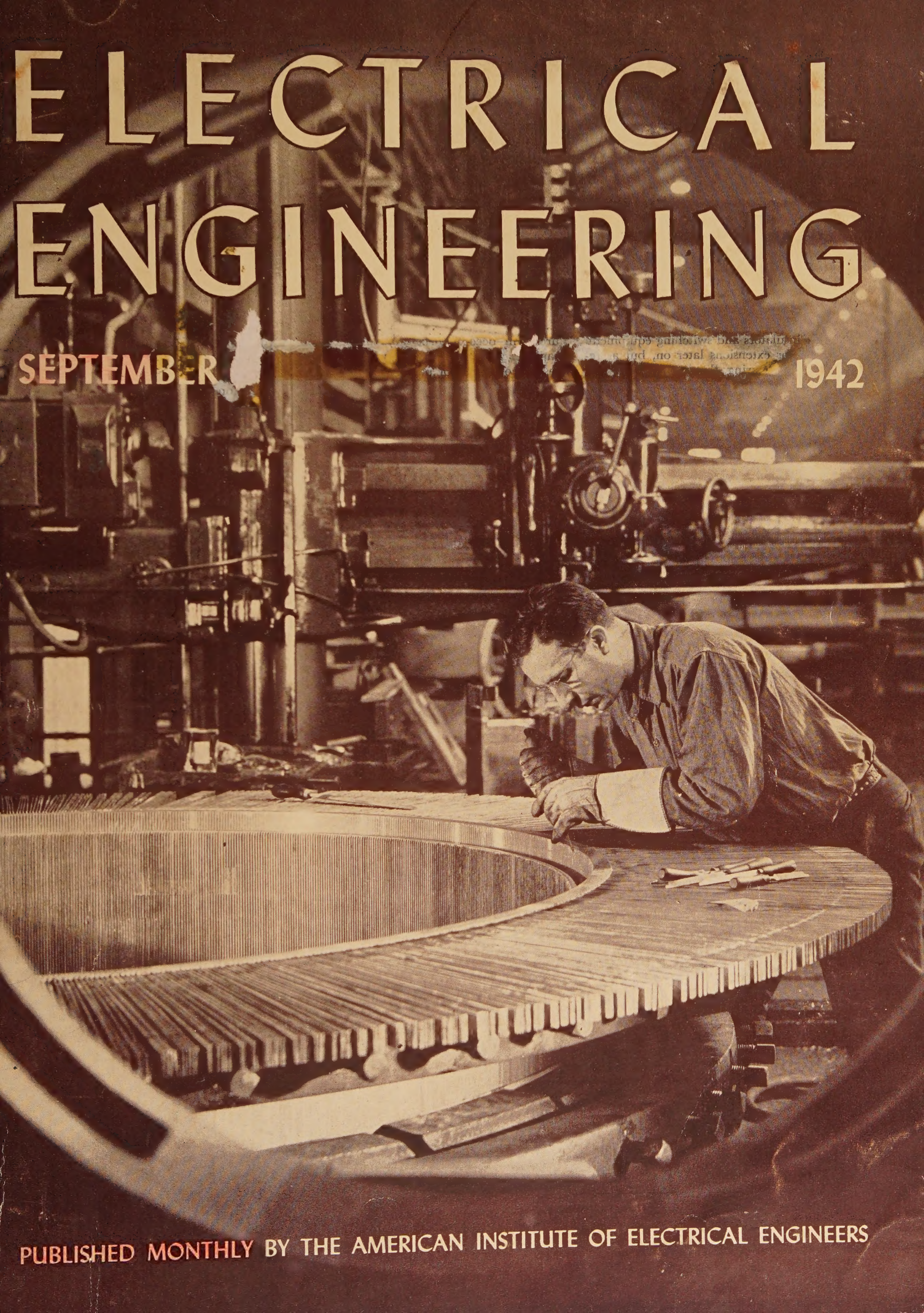
ELECTRICAL ENGINEERING

SEPTEMBER 1942



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ELECTRICAL ENGINEERING

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SEPTEMBER
1942

The Cover: The electrical-manufacturing industry produces equipment vital to many phases of the war effort. Here the commutator of a 5,000-horsepower steel-mill motor is being assembled.

Photo Courtesy Westinghouse Electric and Manufacturing Company

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HIGH LIGHTS • •

Overloading Transformers. Tests have been made of effects of time and temperature upon transformer insulating materials immersed in oxygen-free oil, protected from exposure to oxygen by means of nitrogen atmospheres with results that include definite evaluations of the effects of acidity on insulation strength; a method of translating given deteriorations of insulation into overloads of given durations has been developed (*Transactions pages 669–73*). The effects of the characteristics of specific apparatus, ambient temperature, load factor, supplemental cooling, and so forth, on load capability of transformers and voltage regulators are considered for both normal and emergency conditions with a view to meeting present and new load requirements, thus conserving critical war materials (*Transactions pages 692–4*). A report on the revision of section 4, Instrument Transformers, of the Proposed American Standard for Transformers, *C*-57, presents the reasons for the establishment of overcurrent requirements of current transformers for relaying service, and for the revised method of specifying the accuracy of instrument transformers for metering service (*Transactions pages 698–706*).

Compression-Type and High-Pressure Cables. Experimental installation of armored compression cable has indicated that the increase in conductor size and temperature range does not hamper the operation of the cable, and that this type of system is well suited for loads of 100,000 kva or more (*Transactions pages 652–7*). Nonleaded high-pressure gas-filled cable can be designed and manufactured to operate with equal success in steel pipe and can be installed without the insulation being harmed by atmospheric exposure or mechanical handling (*Transactions pages 658–65*).

Electric-Powered Pipe Line. A new 1,260-mile petroleum-products pipe line, utilizing 30,000 horsepower in motors, affords flexibility for present schedules and future expansion, safe handling of hazardous petroleum products, co-ordination of electric apparatus to pump requirements, and an efficient system of control (*Transactions pages 638–44*).

Driven Rods and Counterpoises. The relative merits of the driven rod, the continuous-parallel counterpoise, and the radial counterpoise in high-resistance soil were evaluated in a test setup to determine the ground-circuit arrangement best suited to carry lightning currents with a minimum potential across the line insulators (*Transactions pages 628–34*).

New Instrument Jewel. The technique of manufacturing a new jewel for the bearings of electric indicating instruments has been developed, with carefully controlled dimensions and satisfactory impact strength; these jewels can be made in sufficient quantities to replace the large number of sapphires formerly imported from Europe (*Transactions pages 673–6*).

Fault-Detecting Relay. A relay is now available that will recognize the existence of a single-phase-to-ground fault to the exclusion of all other types of faults where the zero-sequence impedance of the system exceeds the negative-sequence impedance by a reasonable margin (*Transactions pages 677–80*).

Nonlinear Series Circuits. A study has been made of the effect of switching time on the current response in a simple nonlinear series circuit with a saturable inductor, and the effect of initial flux linkages in the inductor on the current response during the first few cycles after the switch is closed (*Transactions pages 625–7*).

Poles and Pole Treatment. The necessity for a broader use of available types of poles, particularly in sizes required for joint use of power and communication lines, is pointed out in a paper which discusses pole use, the natural supply of raw material in the forest, and preservative treatment of poles (*Transactions pages 685–91*).

Quality Control. The United States Army Ordnance Department controls quality of munitions during manufacturing, grading, and measurement; its experience has been surveyed from the first experimental application to present plans to encourage nationwide use of the technique in ordnance plants (*pages 449–52*).

Technical High School. The technical high school combines practical laboratory and construction work with a study of mathematics and science, and aims to train boys for constructive work both in industry and engineering college (*pages 452–7*).

Eddy Currents. A simple and accurate method is presented of calculating the paths of the eddy currents and the torque of a relatively thin conducting disk rotating between the pole pieces of a permanent magnet or an electromagnet (*Transactions pages 681–4*).

Transients. A recent field survey of several representative electric-power systems discloses that transient recovery-voltage conditions in connection with the interruption of short circuits are more severe than was previously suspected (*Transactions pages 666–9*).

Control for 40,000-Horsepower Motor. Automatic control equipment developed for a 40,000-horsepower induction motor provides reliable means, by use of proved apparatus, for performing all the necessary starting, stopping, speed control, and protective functions (*Transactions pages 634–8*).

Compressed-Air Breakers. Advantages of the use of compressed air as a source of power to close circuit breakers include flexibility in design and compactness of the unit, avoidance of heavy closing currents, and an increase in breaker speeds, especially in reclosing (*Transactions pages 695–8*).

AIEE Wartime Policies. AIEE wartime policies have been formally defined and clarified with emphasis on the co-ordination of Institute activities with the war effort (*page 477*).

Switchgear Standards. Standard test voltages for indoor and outdoor circuit breakers, disconnecting switches and bus-bar supports, and assembled switchgear have been formulated by the AIEE protective devices committee (*pages 478–9*).

Engineering and Public Service. In a time when values need to be clearly defined, the views of several outstanding persons on the engineer and the engineering method are of more than usual interest (*pages 465–8*).

High-Frequency Concepts. Characteristics of electricity when the frequency of alternation reaches the range of billions of cycles per second are examined in relation to some basic electrical concepts (*pages 461–4*).

Pilot-Wire Circuit Protection. A new tool has been analyzed, the two-winding neutralizing transformer for dissipating disturbing voltages that are frequently impressed on pilot-wire circuits (*Transactions pages 645–52*).

Substitute Materials in Fluorescent Lighting. High-intensity fluorescent local lighting in many manufacturing plants have light-hoods or reflectors which are now made of fibrous materials in place of steel (*pages 458–60*).

Control of Load Swings. A new method of dispatching generator load changes which considerably reduces the magnitude and occurrence of load swings has been devised (*Transactions pages 623–4*).

Powder Metallurgy. Tests with powder metallurgy have revealed the relative importance of time, temperature, and pressure in the sintering of various materials (*pages 468–75*).

Officers and Committees. National AIEE officers and committees, and Section and Student Branch officers chosen by the Institute for the year 1942–43 are listed in this issue (*pages 483–7*).

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Quality Control and the War

LESLIE SIMON

Experience of the United States Army Ordnance Department in applying quality-control techniques to wartime production of munitions has conclusively demonstrated the value of the method, according to an officer in the Department.

MANY PEOPLE who have a technical or friendly interest in quality control ask me: What is the Government doing in the way of quality control? To what uses is it put and in how many places? What is the attitude of the Ordnance Department toward quality control? What benefits does the Government get or hope to get from quality control? I shall present my answers to some of these questions somewhat after the manner in which many people read magazines; that is, first, a brief perusal from the last part to the first, followed by a more deliberate progress from first to last with a knowledge of the direction in which one is moving.

SUMMARY OF QUALITY-CONTROL ACTIVITIES

With the possible exception of one or two of the largest industrial users, the Ordnance Department has more people engaged in the application of quality control techniques than has any other single organization. This high standing not only is true as to numbers, which may include subprofessional or clerical personnel engaged merely in computing data and plotting quality-control charts, but applies in even greater measure to the proportion of highly skilled statisticians who also possess technical knowledge of the sources of their data and who *entertain a wholesome and objective view of the practical engineering end to which their technical skill is merely a means.* I noticed in the last roll call of the Institute of Mathematical Statistics that more members of that organization are employed at Aberdeen Proving Ground than at any other single establishment.

There are three principal uses of the quality-control technique: control of quality of products during the process of production; a highly specialized use termed the control of measurements; and a third use which might be termed quality determination, or grading of product. Control techniques are not confined to the manufacturing arsenal, but extend to the proving ground, the laboratory, and to the central offices of the Ordnance Department. The Ordnance Department's attitude towards quality control, so far as I can judge, consists of definitely favoring it in Ordnance establishments where it has been found to be of practical use, of offering encouragement and aid to independent establishments that wish to attempt its use as a means to produce more and better munitions, and finally of a wholly impartial attitude towards all producers, whether they use statistical methods for quality control or not, as long as they produce good Ordnance products. Wholesome benefits are now being reaped from this technique, not only by way of more uniform products (and uniformity is a most important quality characteristic of munitions) but also in economy and speed in production. The benefits that are hoped for will become obvious with the more detailed discussion of the origin, progress, and plan for further use of quality control in the Ordnance Department.

PROCESS CONTROL

The use of quality control in the Ordnance Department began at Picatinny Arsenal about seven years ago. This application was motivated from the top down, which I believe is the manner in which most applications must be motivated. Only the management has the breadth of vision to foresee results and the authority to institute change. The influence for change arose from conversation between the officers in command and Doctor Frank Jewett, then president of the Bell Telephone Laboratories. This first application was characterized by a total absence of statistically trained personnel. However, after a careful study of Doctor Walter A. Shewhart's book,[1] a study of the production lines from the viewpoint of quality control (including many trial runs), and after a great deal of advice most generously given by Doctor Shewhart himself, a quality-control system was devised for the production of munitions which operated successfully without material change for about six years. During the last year, under the able direction of Captain A. C. Cohen, I understand that considerable improvement in the system has been made.

In the clear light of hindsight this first system furnishes an illustration of a good feature that cannot be emphasized too much and of two bad ones that might well be avoided. The good feature is the careful study that was made of the production process and the adaptation of the statistical technique to meet the practical engineering end. Without this objective practicality the experiment almost certainly would have failed, and statistical methods for quality control would have been unceremoniously terminated either by the officer in

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Essential substance of a talk presented by authority of the Chief of Ordnance, United States Army, at the AIEE North Eastern District meeting, Schenectady, N. Y., April 29–May 1, 1942.

Leslie Simon is a lieutenant colonel in the Ordnance Department, United States Army, and director of the Ballistic Research Laboratory, Aberdeen Proving Ground, Md.

charge of the experiment or by his superior officers. The many principles which can be used to guide quality control are so well recognized and established that they have become standardized.[2] But the actual quality-control plan that is put into operation must be tailor-made to the product and process.[3]

One bad feature was the manner of initiation. Partly as a test of the practicality of the system and partly through ignorance, the quality-control system was put into operation on all production lines at the same time. The system was devised, instructions issued, the administrators appointed, and then an order issued that on such and such a day it was to go into effect. It was by extreme good fortune that it did so. A much wiser plan would have been to apply the technique to a few selected production lines under the supervision of a few carefully trained men; to observe it for a period of time in conjunction with the established method of engineering control; to remove the engineering control upon the accumulation of satisfactory evidence that a quality-control technique could carry the load; and, finally, gradually to expand the quality-control technique from production line to production line, along with the gradual training of personnel for its administration. This would have provided a much safer and smoother transition.

The second mistake was a consequence of making the system almost too simple. Because of a lack of better-grade personnel, and in the interest of economy, the procedure was so systemized in detail that practically all of the statistical duties could be performed by personnel of clerical grade. As long as there was no great change in the arsenal, a trained industrial statistician was not needed to administer the system. The mistake consisted of not providing for the presence of at least one industrial statistician. A change in officers allowed the system to fall into the hands of the subprofessional personnel who were gathering the data and posting the charts. This condition resulted in two ill consequences. First, there was no articulate exponent of quality control to gather, codify, and present factual data on its advantages, to present its gains in authoritative form to the management, and to apprise other agencies of its benefits. This condition perhaps more than any other accounts for the fact that other arsenals are now just beginning the use of quality control. Second, the system could not be expanded to meet war conditions until a trained statistician had been employed and had had time to study the manufacturing processes.

QUALITY DETERMINATION

The second use of the quality-control technique by the Ordnance Department was made at the Ballistic Research Laboratory. This use should be regarded as quality determination rather than quality control. The Ballistic Research Laboratory is charged with the surveillance of ammunition; that is, the detection of deterioration in stocks of ammunition and the grading of lots of ammunition in accordance with their quality. With a view to reducing the cost of sampling and to obtaining more accurate information, the Laboratory undertook a study of the control-chart technique for application to munitions. In this new application of quality control the detection of an assignable cause of variation did not call for the discovery and removal of the cause, but for the firing of more samples of the lot of ammunition to determine its quality more accurately. Such a distinctively different use may call for a quite distinct change in the usual concept of action limits, as the balance (see page 11 of reference 3) between the cost of the consequences of looking for assignable causes of variation which do not exist, and of not looking for causes which really do exist, may be considerably altered. After much careful study and many trials in parallel with the old system, the plan was officially investigated by high officials of the Ordnance Department and the statistical method for the surveillance of ammunition was made the official system of the Ordnance Department. This plan has operated successfully for over four years, and the reputation which it has built up for the economy and precision of the statistical method is largely responsible for the existing large-scale use of quality control in the Ordnance Department.

At about the time the surveillance system was getting under way, the officers at the Laboratory and some of the officers at the central office began to realize that the benefits which accrued from industrial statistics were limited by the difficulty of obtaining statisticians with an engineering or physical-science background, not to mention a background in the technical field to which their statistical method is to apply. Therefore, it was decided to gather into the Laboratory some of the best young statisticians obtainable and deliberately train them in technical ordnance, while at the same time having them perform the duties connected with the surveillance system. This move has provided the Ordnance Department with at least a few trained men to meet the pressing demands that now exist.

THE CONTROL OF QUALITY OF MEASUREMENTS

The major activity of Aberdeen Proving Ground is the proof-testing of all arms and ammunition except small arms for the Army. During the development of the surveillance system it became apparent that the statistical method was of great use to the Laboratory in supplying advice to the proof department regarding the more technical phases of this work. Finally, it became apparent that there was a very real need for statistical methods in the control of the Proving Ground's product, namely, measurements. If the Proving Ground's measurements are subject to assignable causes of variations, erroneous conclusions may be drawn with regard to the results of tests. As a result of the wisdom and foresight of the chief proof officer, Colonel George G. Eddy, the

Laboratory was called upon to assist in the design of a system for the control of Proving Ground measurements. This system is similar in many respects to that usually found in the control of quality of manufactured product. It has operated with marked success under the capable and energetic supervision of David Kinsler, formerly of the Bureau of the Census. It operates so as to segregate variations due to materiel being tested from variations due to instruments and personnel. I think it is a marked tribute to this system that the precision of Proving Ground measurements today is slightly better than it was a year ago, especially when one considers that during the past year there has been a huge expansion in personnel. Almost all new personnel are inexperienced and untrained. The statistical method has contributed much in making possible the efficient use of these new people.

THE APPLICATION OF QUALITY CONTROL TO ACCEPTED PRODUCT

By the time the defense emergency began, the evidence gathered from quality control at Picatinny Arsenal, surveillance at the Ballistic Research Laboratory, and control of measurements at the Proving Ground was sufficient to lead to the conclusion that existing acceptance specifications are not a sufficient basis for making the most economic use of procured materials. Therefore the Ordnance Office called upon the Laboratory to provide the necessary quality-control techniques for the Inspection Section of the Ammunition Division. This is a huge task which runs on a huge scale. A separate technique must be provided for each item of ammunition. The results are analyzed in the Ordnance Office in accordance with these techniques and a great deal of important information not heretofore available is brought to light.

THE CONTROL OF QUALITY OF COMPLETE ROUNDS OF AMMUNITION

While the steps just described are another instance of quality determination, they made possible a most effective use of quality control in the war effort. Early in the war effort, two bottlenecks in the procurement of ammunition developed. Bottleneck number one was directly attributable to measures that are taken to insure the uniformity of lots of complete rounds of ammunition. A lot of complete rounds of ammunition must of all things be uniform, otherwise the artillerymen's adjustment of fire is entirely spoiled. The effectiveness of the fighting forces may be distinctly impaired by nonuniform lots. Therefore, it has long been required that each lot of complete rounds contain fuses from one lot of fuses, boosters from one lot of boosters, and so forth, for practically all components, of which there are a considerable number. It is difficult enough to make one's bread and molasses come out even, but when there are a half dozen kinds of bread and molasses, the problem is greatly aggravated. The component lots are generally limited in size to some relatively small number. Therefore, it is easy to see that the complete-rounds manufacturer does not get very far before he exhausts the lot of primers which he is using. This calls for the beginning of a new complete rounds lot. Then he may run out of boosters. Next he may run out of powder, and so forth. Consequently, lots of complete rounds tended to be small. This meant loss of time for the complete-rounds manufacturer, because he had to clear his production lines of all units of the old lot before beginning a new lot. Lot cards had to be printed and closed out. Other essential functions pertaining to the complete-round lot had to be performed. Furthermore, for every lot of complete rounds a sample had to be tested at the Proving Ground, which led to bottleneck number two. The Proving Ground became congested and both production and shipment of ammunition were threatened with delay unless proof-testing could be greatly expedited. These conditions led to a conference at Washington where the troubles were presented and a solution sought.

The statistical technique made the solution easy. The experience gained from surveillance techniques showed that the separation of components, such as fuses, boosters, and so forth, into successive lots was often nothing more or less than periodic division with respect to time. That is, the differences between lots were no greater than differences within lots. However, lot sizes had to be limited because no one could foretell how long the manufacturer could continue to make articles that were essentially alike. With the statistical technique set up in the inspection section of the Ammunition Division it was quite easy to tell how many lots a manufacturer had made that were essentially alike. An aggregation of lots that are essentially alike is termed a grand lot. Therefore, all the Ordnance Department had to do was to capitalize on its statistical technique, and instead of requiring, for example, that all fuses in one lot of complete rounds be of the same lot, require that all fuses be of the same grand lot. This enabled production of large lots of complete rounds without any loss in uniformity. It saves time and money to the complete-rounds manufacturer, saves time and money in testing at the Proving Ground, relieves congestion at both places, and provides the artillerymen with bigger and better lots of complete rounds.

RECENT DEVELOPMENTS IN THE ORDNANCE DEPARTMENT

The most recent development in the Ordnance Department is attributable to Doctor Shewhart, Captain Cohen, and several others who talked together at the last meeting of the Institute of Mathematical Statistics. They realized that they, the Laboratory, and the Proving Ground were being burdened with a large number of questions from various persons and establishments regarding the use of quality-control techniques in war industry. As a result of their initiative, a letter was written by the Commanding General of Picatinny Arsenal which resulted in a conference at the Ballistic Research Laboratory which, in turn, resulted in calling this condition to the attention of the Chief of Ordnance. There has now been established in the office of the Chief of Ordnance an organization, under the direction of G. D. Edwards of the Bell Telephone Laboratories, for co-ordinating the efforts of various departments and establishments with respect to quality-control techniques. All divisions of the Ordnance Office and all establishments employing quality control have representatives for contact with this organization. In this way, an exchange of ideas is effected, assistance in difficult phases of problems is obtained, and inquiries from various sources are passed along to the central body for authoritative answers.

FUTURE DEVELOPMENT OF QUALITY CONTROL

Present progress has been so fruitful that plans are now under way definitely to encourage quality-control techniques in the establishments under the control of the Ordnance Department. The next step probably will consist of having each Ordnance district, of which there are 13 blanketing the country, appoint officers and civilians as quality-control representatives and to give these representatives a brief course in the principles of the quality-control technique. These men will provide a leaven or nucleus of quality-control men in their respective districts, to review critically the results of inspection of material, to criticize inspection practices and establish better ones, and to organize quality-control methods on selected lines in various munitions industries. From these, the quality-control method of inspection can be spread line by line until its benefits are extended at least to the greater percentage of those inspection operations where it may prove effective.

THE ASA AND QUALITY CONTROL

Attention should be called to some of the factors that have contributed to the extensions of the benefit of quality control to the war effort. Aside from the collective effort of the individuals who work in this field, I believe that the greatest single contribution has been the action taken by the American Standards Association in issuing the new Emergency Defense Standards for quality control. Without such official recognition on the part of that authoritative agency I doubt if the higher officials of the Ordnance Department could have been persuaded to take the action just described.

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2. Guide for Quality Control, Z1.1—1941. American Standards Association, New York.
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The Technical High School Trains for Life

C. E. CROFOOT
MEMBER AIEE

THE technical-high-school movement has been growing steadily throughout the United States and Canada for the past 25 years. However, it has apparently been stronger in the East than in the West, probably because of the heavier concentration of industry in the eastern cities, since the technical high school trains directly for industry. The enrollment in these schools jumped considerably after the last war and it has risen sharply during the past two years. The total technical-high-school enrollment for New York State rose from 309 in 1921 to over 15,000 in 1942. Similar increases probably have been shown in other states. They were caused in large measure by the efficient training provided by these schools and the more effective laws regulating them.

The primary aim of the Mont Pleasant Technical High School at Schenectady, N. Y., is to train boys to become efficient members of the group of technicians, service men, and junior assistants to engineers, architects, and service production managers in the highly technical or junior-engineering branches of industry. Our curricula are, however, so designed that the cultural side is not neglected. We feel they should be so planned that the door to college is kept open for those who can afford or profit by it and that any course, either academic or technical, should build good citizens.

Our technical curricula are naturally designed to provide a good foundation in mathematics, science, drafting, and technology, which are all essential to future growth in the technical fields of modern industry. They also require the same high-school English, history, and economics that are found in our college-preparatory academic courses. Only the foreign language is left off the required list, to make room for some of the technical subjects.

Essential substance of a paper presented at the AIEE North Eastern District meeting, Schenectady, N. Y., April 29–May 1, 1942.

C. E. Crofoot is head of Mont Pleasant Technical High School, Schenectady, N. Y.

The technical student also spends considerable time in the shop and laboratory, so that he learns by doing. As a result, our graduates can enter either industry or engineering college with equal facility. The technical students attend school one hour per day longer than do the academic students.

Based on the belief that boys interested in engineering should have an opportunity to do practical work at the same time that they are learning the elements of mathematics and science, technical-high-school curricula, as exemplified in Mont Pleasant Technical High School, Schenectady, N. Y., have proved very successful in preparing students for work in local industries. The same courses have also shown their effectiveness as preparation for engineering college.

The technical high school is not a technical institute, even though much of our instruction and laboratory equipment are patterned after those of the institute. Our students are accepted directly from the junior high school, while the technical institute accepts them from the senior high school only. The work, however, is all of high grade and can be mastered only by the better students. They must have a mathematical and scientific turn of mind or they will fail.

NEED FOR A TECHNICAL HIGH SCHOOL

Changes in methods of production, increased use of power, and invention of labor-saving machines have brought about a very definite need in most industrial communities for boys of technical-high-school grade. In fact, several technically trained men of less than college grade are required for each engineer. This is particularly true in centers like Schenectady. The technical-high-school graduates will often do a better job than the engineering graduate would on much of the practical but very important developmental work in general-engineering and research laboratories, because they have more skill in the actual handling of equipment and also because they are relatively more adapted to such jobs.

For this reason, the most successful technical high schools are those which maintain very close co-operation with local industries. This brings up one of the most distinct differences between the technical high school and the engineering college. The average college places the larger percentage of its graduates in industries far removed from the college, and those industries have a wide diversity of requirements. Practically all the technical-high-school graduates are placed in the immediate vicinity of the school from which they are graduated. The reaction to poorly trained graduates is, therefore, quick and fatal, if the school has not adapted its technical training to the needs of local industries through careful co-operation. Technical training must also be fundamental enough that the employer can shift the boys from one job to another when conditions make this necessary.

PRINCIPAL TYPES OF TECHNICAL HIGH SCHOOLS

There are two general types of technical high schools in operation in New York State. The first type is found in such cities as New York, Yonkers, Rochester, and Buffalo, which are large enough to support separate buildings, and have funds and students enough to make them effective units. The second, and more common type, is the comprehensive high school, like Mont Pleasant Technical High School, which is really a school within a school. The technical group usually numbers around 400 boys out of a school averaging about 1,900 students, with the academic section about equally divided between boys and girls. A school of this size can offer many more opportunities for leadership and extracurricular activities than would be possible with a unit of only 400 boys and no girls to balance a social-activity program.

It is, of course, true that an unsympathetic academic principal can exert a depressing or retarding influence on the technical group, but fortunately such cases are few if the technical department does a thorough job of training. We are extremely fortunate in Mont Pleasant High School in having a broad-minded academic principal who has maintained a very sympathetic attitude toward our technical group. He has recognized from the first that only boys of the highest mental caliber can handle the technical work and has been a great help by constantly steering good boys with a scientific and mathematical bent into our courses. He has taken pride in the fact that about one third of the graduating-class presidents have been boys from the technical course.

There are some disadvantages in fitting the technical and academic daily schedules together, due to the longer technical day and double shop or laboratory periods, but a wholesome co-operation between the faculties of both parts of the school will overcome these difficulties. The main advantage is that of having the technical boys take their English, history, economics, and other non-technical courses, in the same classes with the academic boys and girls. Thus each group has a chance to see that there is nothing peculiar about the other. Each group is a good check on the other. This cannot be done if the groups are in separate buildings. The comprehensive school also affords an opportunity for any technical boy to take a foreign language as an extra subject if he wants it for entrance to some particular college, or for its cultural value. It also shows the college-preparatory student that only boys with the highest mentality can handle the technical course. When they are in separate buildings the college-preparatory student is likely to look down on the technical student. This way he is forced to compete with the technical boy and finds him more than a match.

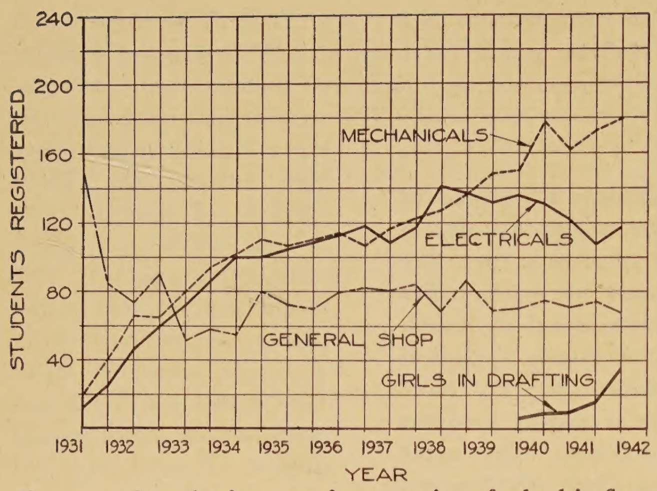

Figure 1. Growth of courses from opening of school in September 1931, to date. Mechanical group shows influence of war

There is relatively much more in common between a senior academic high school and a technical high school than between an industrial vocational high school and a technical high school. The industrial high school attracts boys who are more "hand-minded" than mathematically or scientifically inclined, so the emphasis must be placed on training in manual skills. When these students are combined with a technical group, the result is usually to lower the standard of the technical school.

TRAINING GIRLS IN DRAFTING

The present war emergency has shown another distinct advantage of the comprehensive high school. When industry called for girls to work as tracers and clerks in drafting rooms it was an easy matter to enroll a number of girls from the commercial and other academic groups for training in the drafting classes. Over 85 per cent of these girls have been placed in drafting positions during the year and a half and our enrollment has increased each term.

TYPE OF INSTRUCTOR REQUIRED

It is very difficult to find good technical teachers. New York State requires an engineering education, plus at least three years of practical engineering experience in industry after graduation. The men must also add 18 hours of teacher training at colleges which meet the state requirements for this work. These requirements help assure a better theoretical and practical training for technical boys, as well as better vocational guidance which is the result of actual industrial experience.

The technical instructor must be prepared at all times and must know his subject so well that he will command respect from his students. The best all-around electrical instructor is the man who has been a service-shop or road engineer for some manufacturing company. He has had to make things work in the field under difficulty, and to correct the mistakes of the designing engineers so that the customer will be satisfied. Such experience develops resourcefulness and a wealth of information about the application of electricity to a number of other industries. This accumulated information broadens an instructor so he can then train boys for more than one branch of electrical work.

An instructor with this experience and background can be of invaluable help in guiding boys into lines of work for which they are particularly well adapted. He can also analyze them and help the principal to write recommendations that will be of real value to an employer in placing a boy in the right department.

IMPORTANCE OF LABORATORY AND SHOP EQUIPMENT

Next to the instructor comes the equipment, as both are essential to a successful technical high school. The best-trained instructors will fail without complete, well-chosen equipment with which to work. Two things must be borne in mind in selecting the equipment for such schools: first, that the instruction must emphasize the application and use of apparatus; second, that a technical-high-school boy spends relatively much more time in the laboratory and shop than does the average college student. In the first place, a student learns more about the characteristics of a piece of apparatus by actually working with it than in any other way. Unless sufficient equipment is provided to keep the whole class working all the time, the instructor will have a serious discipline problem and will turn out a shiftless lot of boys because they have learned to loaf in the laboratory.

EFFECTIVE APPRENTICE TRAINING

The technical high school, with its experienced instructors, practical equipment, and drafting rooms is of great value in a community as a co-operative training center for local industries.

For example, the technical-high-school faculty and equipment are both especially well adapted for industrial apprentice instruction which should be carried on

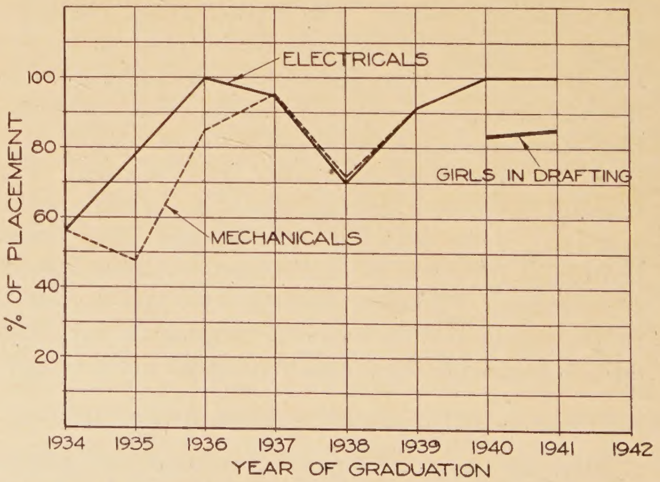

Figure 2. Placement of graduates from first class in 1934 to date

Table I. Apprentice Training Curriculum

Term		Hours Per Week	Term		Hours Per Week
	First Year			**Second Year**	
I	Shop mathematics I	2	I	Trigonometry I	2
	Algebra	2		Mechanics (shop)	2
	Drawing	2		Metallurgy	2
II	Shop mathematics II	2	II	Trigonometry II	2
	Geometry (plane)	2		Machining of metals	2
	Drawing	2		Strength of materials I	2
III	Shop mathematics III	2	III	Descriptive geometry I	2
	Physics (advanced)	2		Mechanics I	2
	Drawing	2		Strength of materials II	2
	Third Year			**Fourth Year**	
I	Descriptive geometry II	2	I	Machine design II	2
	Mechanics II	2		Analytic geometry I	2
	Electricity I	2		Electricity IV	2
II	Mechanics III	2	II	Machine design III	2
	Kinematics I	2		Analytic geometry II	2
	Electricity II	2			
III	Machine design I	2	III		
	Kinematics II	2			
	Electricity III	2			
Elective					
	Tool and die design				
	Calculus				

in co-operation with industry. The actual machine or shop instruction should be given by the industry itself. The following apprentice curriculum, offered by the Mont Pleasant Technical High School, is a good example of this type of co-operative training. The present enrollment in this course is over 500 apprentices, and all classroom training is planned to correlate closely with work at the shop. The apprentice can then put it to immediate use in the shop and thereby clinch it in his mind.

TECHNICAL-HIGH-SCHOOL CURRICULA

The following day-school curricula are offered at Mont Pleasant Technical High School. They are three-year courses designed to follow the ninth grade or junior high school. The mathematics and science are all taught by men who are trained engineers, and who give the subjects a practical application.

These subjects represent a difficult schedule for a boy to carry, but we have always maintained that "cinch courses" will not attract high-grade, ambitious boys and that loafers are not looking for hard work. The truth of our supposition has been borne out by the fact that over 35 per cent of all the boys on the school honor roll come from the technical group, although it includes only 27 per cent of the total enrollment of boys.

A general shop course is offered for boys who cannot handle the exacting work of the technical courses. These boys have no special curriculum requirements, but are allowed to elect their own courses and take what shop work they wish, on sheet metal, wood work, molding, lathe work, and automobile mechanics. Direct placement is very low in this group except in unusual times such as we now have. They are shown on the growth chart as "nontechnical."

The boys are urged to take the state Regents' examinations in English, history, economics, science, and mathematics, to make them readily acceptable in engineering colleges if they later decide to attend college. In addition, a six-hour Regents' comprehensive technical examination is given at the end of the course.

All technical instruction given must be immediately applicable to the future work in industry, or student and employer reaction will be most unfavorable to the school.

BOYS LEARN TO THINK AND BECOME SELF-RELIANT

The technical high school should emphasize the practical use or application of industrial equipment and processes. The design of such equipment is a job for the engineer. For this reason, the technical boy should be trained to use his head and hands together. If he cannot do this, his progress will be slow at first. This is particularly true of the electrical student. If he can build special test apparatus and work out intricate circuits, he is not only a great help to the engineer for whom he works but sooner or later will develop new and useful ideas of his own. This work brings the boys into close association with designing engineers, which is an education in itself.

A thorough technical training in high school helps a boy to develop ingenuity and the ability to analyze a problem and to think logically, as well as to contribute his part to a co-operative enterprise. All of these become natural for him because he must early learn to work in a group of from two to five boys in the laboratory. These groups are put on their own. They must make decisions and be willing to take the responsibility for them, since

Table II. Curriculum for Electrical Students

Entrance Requirements: Pupils must have completed the ninth year in junior high school, including elementary algebra

Term I	Periods Per Week	Term II	Periods Per Week
First Year			
English 10B	5	English 10A	5
Plane geometry B	5	Plane geometry A	5
Applied drafting 1B	10	Applied drafting 1A	10
Electrical theory 1B and electrical shop	10	Electrical theory 1A and laboratory	10
Physical education	5	Physical education	5
Study	5	Study	5
Second Year			
English 11B	5	English 11A	5
Intermediate algebra B	5	Advanced algebra or solid geometry	5
Applied drafting 2B	10	Plane trigonometry	5
Electrical theory 2B and laboratory	10	Electrical theory 2A and laboratory	10
Physics B	7	Physics A	8
Study	3	Study	7
Third Year			
English 12B	5	English 12A	5
American history B	5	American history A	5
Economics	5	Mechanics (with lab.)	10
Electrical applied math	5	Electrical theory 3A and laboratory	10
Electrical theory 3B and laboratory	10	Electronics	5
Study	10	Study	5

Note: Exceptional boys may also elect applied drafting, machine design, strength of materials, chemistry, a foreign language, or other academic subjects instead of study period.

Table III. Curriculum for Mechanical Students

Entrance Requirements: Pupils must have completed the ninth year in junior high school, including elementary algebra

Term I	Periods Per Week	Term II	Periods Per Week
First Year			
English 10B	5	English 10A	5
Plane geometry B	5	Plane geometry A	5
Applied drafting 1B	10	Applied drafting 1A	10
Materials of industry Machine shop theory	10	Machine shop 1B	10
Physical education	5	Physical education	5
Study	5	Study	5
Second Year			
English 11B	5	English 11A	5
Intermediate algebra B	5	Advanced algebra or solid geometry	5
Applied drafting 2B	10	Applied drafting 2A	10
Physics B	7	Plane trigonometry	5
Machine shop 1A	10	Physics A	7
Study	3	Study	8
Third Year			
English 12B	5	English 12A	5
American history B	5	American history A	5
Economics	5	Machine shop	10
Mechanical applied math	5	Machine design	10
Mechanics (with lab.)	10	Strength of materials (with lab.)	10
Study	10		

Note: Exceptional boys may elect chemistry, electricity, a foreign language, or other academic subjects instead of study period.

a wrong decision may mean the destruction of valuable apparatus, or injury to a fellow-worker or to themselves. It becomes easier for the graduates to meet people and converse intelligently with them, as well as to remain open-minded. All these things contribute to self-reliance and trustworthiness, based on a level-headed consideration of the facts involved.

The technical student has a distinct advantage in engineering college over the academic college-preparatory student. Since he has used his mathematics and science in his technical work all through high school, they are second nature to him when he reaches college. He knows how to apply them. The academic student simply studies them long enough to pass an examination and moves on to another subject, and the mathematics and science are forgotten by the time he reaches college. The technical boy has also found himself, and knows what he wants to be before he enters college. While we do not train primarily for college, an average of about 12 per cent of electrical and 10 per cent of mechanical students do go to engineering college and more than 95 per cent are graduating in four years, as against half that percentage from academic college-preparatory courses.

The boys seem to enjoy thoroughly the technical curricula, in which there is a balance between the cultural subjects, such as English, civics, history, economics, and the applied technical work. This balancing of subjects adds interest to the day's work, since the wide range of subjects covered tends to break up the frequent monotony of school work. The free discussion of the work in the laboratories between boys of a given laboratory group and between the groups and their instructor helps develop their personalities and the ability to express themselves which is so important in life.

SOME TANGIBLE RESULTS

The foregoing discussion has shown what we are trying to accomplish at Mont Pleasant, and the manner in which we are carrying out our ideas. It therefore may be of interest to offer some comments on the records of our graduates in order to present a picture of the results thus far.

After Mont Pleasant Technical High School was opened in September 1931, with a registration of 12 electrical and 18 mechanical students, the enrollment grew steadily for three years, and thereafter has been maintained at the desired levels as our facilities have been enlarged, with applicants being turned away each year.

The graduation of the first class in June 1934 marked a turning point in the development of the course, for in spite of the depression, nearly 60 per cent secured immediate employment in jobs for which they had trained. The consistently fine records of the first graduates initiated a greater demand from employers, as well as greatly increased the popularity of the course with students. A healthy growth is shown by the graph in Figure 1. It also shows how the war has unbalanced the load between electrical and mechanical groups. They all want to be machinists now, even though we cannot begin to get enough electrical graduates.

Placement of graduates in suitable jobs is an important function of a technical high school. A transcript of the school record of each graduate is sent to all the principal

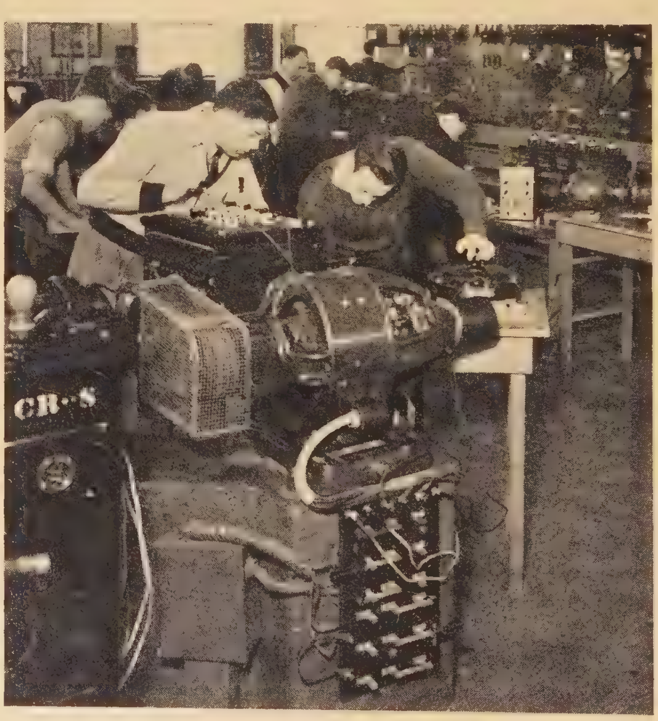

Figure 3. Boys at work in the electrical laboratory. Motors and projects on table at right are made by boys

employers of the area, together with a very frank, honest and complete appraisal of the student's character, aptitudes, and a summary naming one or two types of work for which he is best qualified.

These recommendations have proved so accurate that they are now much appreciated by employers as well as by students, and have proved an important factor in helping the graduates to obtain positions best suited to their abilities. Graduates are invited to report periodically on their status, and they have done so practically without exception. This practice helps to maintain their interest in the school and also brings us many new recruits. Employers now come to the school ahead of graduation with a list of their requirements.

Records are kept at the school for at least the first three jobs of each boy and the file so maintained contains many interesting personal stories. By this follow-up system, many boys who could not secure just the positions they wanted at first, because of the depression, have later been placed more effectively. Among the hundreds of letters and personal reports that have been received, there is no case of any student's expressing regret that he had taken the technical course rather than some other. Technical-high-school placement records over a period of 20 years show a higher per cent of electrical than mechanical placements when times are poor, as there are more places where one can obtain electrical jobs. The graph in Figure 2 shows the placement record of Mont Pleasant since 1934.

Boys who have gone on to engineering schools after graduation from the Mont Pleasant High School course have been particularly enthusiastic, saying that the practical training they received not only enabled them to maintain better records in college, but also was of great benefit in securing part-time employment of a character helpful in their further education.

The boys seem to be impressed with the fact that a clear understanding of the basic sciences and how they apply to our modern way of living is as much an element of culture as a knowledge of Greek and Latin used to be. At any rate, the engineer need not apologize for his calling, as it has contributed as much to the comforts and progress of man as has any other field of endeavor.

We feel this plan provides a splendid fundamental training for life, with both college and industrial employment open to the students. In many instances, it has made it possible for a boy to earn his own college education, when otherwise it would have been impossible for him to attend. This industrial experience helps him to appreciate more fully the need of advanced engineering training. He, therefore, goes into college with an attitude that makes him a leader. Our aim is to develop the whole boy and thereby build useful citizens.

Figure 4. A corner of the machine shop with boys at work

Photoelectric System Controls Traffic in Continental Divide Tunnel

A photoelectric block-signal system controls the traffic of men and materials which constantly flows in both directions in the 13-mile-long $50,000,000 Continental Divide Tunnel now being drilled between Grand Lake and Estes Park, Colo. Part of the Colorado–Big Thompson project of the United States Bureau of Reclamation, this tunnel will bring water from the western slope of the Continental Divide to the eastern side, where it will be used for irrigation and the production of electric power.

The trains in the tunnel travel on a 24-inch-gauge single track with passing tracks at convenient intervals. The signal system indicates to train crews the presence of a train in the next section of the tunnel. This prevents accidents and reduces waiting time at passing tracks.

Because the accumulation of water and dirt around switches connected to the rails would impair the efficiency of the signal system and thus cause added expense and delay, and because electric currents in the rails might cause premature ignition of blasting charges, a signal system without mechanical or electrical switches connected to the rails was required. The track, therefore, was divided into blocks of about 6,000 feet, each block ending wherever a turnout occurs for passing. At the beginning and end of each block were placed two photoelectric relays spaced about 30 feet apart, which control the operation of red and green signal lights in that block. Each relay has two light sources located across the track and spaced about 15 feet apart, so that only a locomotive or train can operate the lights.

All green lights are on when the track in a block is clear. When a train or locomotive enters the block and interrupts the light beams directed on the first relay, there is no reaction, since this relay controls the already lighted green lights. When the light beams directed on the second relay are interrupted, however, the green lights are extinguished, and the red lights turned on. The reverse happens when the train emerges from the other end of the block.

This is said to be the longest tunnel in the world protected by photoelectric block signals. The signal system was designed by the General Electric Company.

Substitute Materials in War-Plant Lighting

EDWIN D. TILLSON

To conserve critical materials which would be necessary to build new plants and to save the time required for construction, existing manufacturing plants are being pressed into service for war production. Many of these plants have inadequate lighting facilities. This article suggests that present lighting sources in such plants be supplemented by placing at strategic working points high-intensity fluorescent local lighting with light-hoods or reflectors. These reflectors, no longer made of steel because of wartime restriction, are now being formed successfully from fibrous materials.

IT IS GENERALLY known that a limitation order is being prepared by the War Production Board prohibiting the use of steel for reflectors on fluorescent lighting equipment. The order is being prepared with the co-operation of leaders in the lighting-equipment industry. Without waiting for such an order, many manufacturers have been actively at work on the problem of substitutes, and a few are already in production.

It has been anticipated that the Government will spread the fabrication of war materials over a great number of existing manufacturing premises. Press statements by Government spokesmen in recent months stress the advantages of this program as a move to conserve critical materials required for new building construction and to save the time required to build new defense plants.

INADEQUATE LIGHT IN WAR-PRODUCTION PLANTS

Observation of typical manufacturing plants, many of them built or added to over a period of 50 years, discloses that their wiring and lighting provisions are extremely meager—possibly sufficient from the owners' standpoint for peacetime production during daylight hours, but sadly deficient from the standpoint of workers' efficiency in extensive war production on a three-shift basis.

The typical scene is overhead general lighting from widely spaced fixtures that furnish from 2 to 5 foot-candles, supplemented by local lighting at or near the eyes of the worker, often with exposed or partly exposed lamps that furnish from 15 to 40 foot-candles of illumination over a small area, along with deep shadows, and intrinsic and reflected glare. It is believed that there is not sufficient branch-circuit copper in these places to permit good overhead lighting of 35 to 50 foot-candles, such as we find in all the new defense plants. Neither is the copper available from the outside.

THE LIGHT-HOOD

As viewed by the Utilities Research Commission, an organization sponsored by the four power companies in the Greater Chicago area, the only alternative is to leave the overhead lighting about as is and obtain high-quality, high-intensity fluorescent local lighting at and surrounding all critical working points. The Commission proposes for this purpose, light-hoods (Figure 1) of inexpensive construction, designed for quick installation with a minimum of sheet-steel, pipe, and wire. It was in the development of these light-hoods, or war-hoods as they are also called that the Utilities Research Commission uncovered interesting data on fibrous products.

The conception of light-hoods is not new. They have been successfully and widely used since they were demonstrated by a Chicago group under the chairmanship of Professor H. B. Dates of the Illuminating Engineering Society. This was some eight years ago.

The advent of the fluorescent lamp has revived the interest in light-hoods for the reason that this lamp removes about the only objection there is to the use of the hoods with incandescent lamps, namely, the long-wave radiant energy which, at low mountings, caused considerable discomfort at certain times of the year.

The important point is that light-hoods obviate nearly all of the disadvantages of localized lighting. That is, they are characterized by a very low surface brightness—1 to 1.5 candle power per square inch—and they constitute a large, projected light-source area—16 square feet in the case of URC hoods as compared with from 1/4 to 1/2 square foot for the usual local light source. Light-hoods may be constructed to furnish anywhere from 40 to 50 foot-candles over an area of 100 square feet with a wattage slightly under 200, including auxiliaries. The light is practically shadowless and comparable with the best natural light as obtained from north exposure.

NONMETAL LIGHT-HOODS

Manifestly such large hoods could not be made of steel at this time. Experiments were first made with 1/16-inch slot insulation (Figure 2) which is well known to electrical engineers, having been used for the lining of slots in rotors and stators for many years.

Flat material is ideal from a manufacturing, shipping, and replacement standpoint. It requires no preforming

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Essential substance of an address presented at the AIEE summer convention, Chicago, Ill., June 22–26, 1942.

Edwin D. Tillson is a testing engineer with the Commonwealth Edison Company, Chicago, Ill.

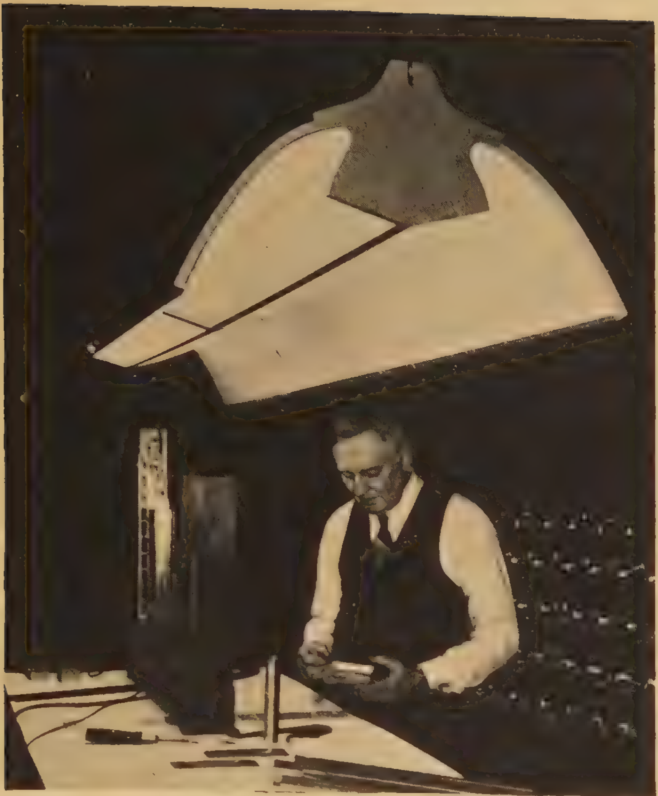


Figure 1. A light-hood with reflector of substitute material

and can be delivered flat and sprung into the proper curve by the user. Extensive trials, however, disclosed that even with careful over-all coatings of enamel, baked on, the fiber absorbs moisture. It expands and contracts after installation, causing warps and buckling.

Manufacturers have offered a material 1/8-inch thick similar to Masonite except that it exhibits a hard smooth surface on both sides—hence the designation S2S (Figure 3). This material is not oil-tempered. It contains a limited amount of plasticizer. Unlike tempered Masonite, this material requires no immersion before forming. Heretofore the forming of Masonite, Bentboard, Weatherboard, and Hardboard, has been done by jobbers in several of the larger cities. Where formed fiberboard is used for furniture, show-window trim, and display booths, there almost always has been the opportunity to frame the object with wood battens. Usually it was possible to conceal these battens or to use them in forming part of the design. These wood battens or framing served to hold the edges of the bent fiberboard in alignment. However, in the case of reflector there are two free edges which cannot be so supported.

METHODS OF FORMING FIBROUS LIGHT-HOOD

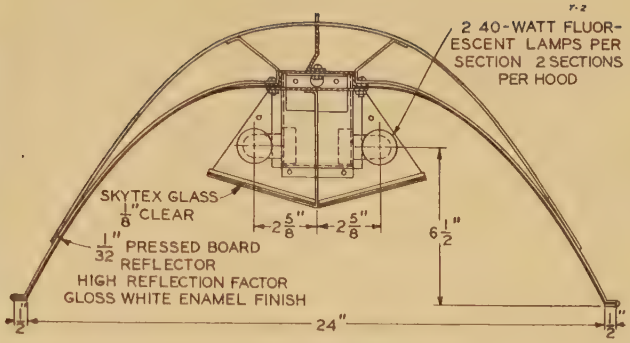

T-2
2 40-WATT FLUORESCENT LAMPS PER SECTION 2 SECTIONS PER HOOD
SKYTEX GLASS 1/8" CLEAR
2 5/8"
2 5/8"
6 1/2"
1/32" PRESSED BOARD REFLECTOR HIGH REFLECTION FACTOR GLOSS WHITE ENAMEL FINISH
1/2"
24"
1/2"

Figure 2. Cross section of a light-hood using slot insulation of hard fiber for reflector

The common method of forming fiberboard has been to place the material between a stationary pipe and a concave shoe or platen. As the material is squeezed between the two, steam is applied to the interior of the pipe raising its temperature to approximately 500 degrees Fahrenheit. The mechanical pressure is obtained through hydraulic jacks. The pipe is kept in alignment by struts from overhead with turnbuckles for final adjustment. The method is illustrated in Figure 4.

Suppose that the shape desired is the typical Reflector Lamp Manufacturers contour as shown in Figure 4. The forming is done as at *A;* then the material is unclamped and shifted to point *B* where the operation is repeated. However, this type of operation is neither fast enough nor otherwise suitable for fixture reflectors. As might be surmised, the internal structure of the material is altered by the pressure and temperatures applied. That is, it is altered over the area in contact with the pipe and the shoe. The structure of the material outside of the areas *A* and *B* is not changed but remains as in the original material as it comes from the mill. The tendency on release from the press is for the flat portions to warp.

It is proposed therefore to build presses for the sole purpose of producing fluorescent-lighting reflectors. These presses will have male and female platens, covering the entire surface of the reflector sheet (Figure 5). In this way all portions of the sheet will be subjected to the same temperature and pressure. Preliminary experiments indicate that although the final reflector may not be absolutely true, it will be commercially acceptable and possibly as free from warp as similar sheet-steel

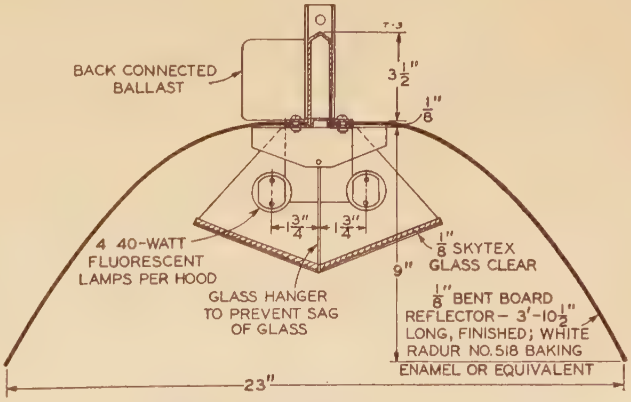

T-3
BACK CONNECTED BALLAST
3 1/2"
1/8"
1 3/4"
1 3/4"
4 40-WATT FLUORESCENT LAMPS PER HOOD
1/8" SKYTEX GLASS CLEAR
9"
GLASS HANGER TO PREVENT SAG OF GLASS
1/8" BENT BOARD REFLECTOR – 3'-10 1/2" LONG, FINISHED; WHITE RADUR NO. 518 BAKING ENAMEL OR EQUIVALENT
23"

Figure 3. Detailed cross section of a light-hood showing use of S2S reflector board

contours. The proposed method is illustrated in Figure 2. It is expected that up to and including the 63-inch reflector, this will be a satisfactory method. It is believed that beyond this length the reflector must be broken up into sections. For example, for the URC hoods the use of two sections per side, slightly separated, is expected.

The S2S sheet may be sprayed with the synthetic enamel of the urea or alkyd type which have become so popular in the last year or so for major appliances and, in fact, for the bulk of fluorescent-lighting fixtures. These enamels are baked on at a temperature of approximately 300 degrees Fahrenheit preferably in a radiant drying tunnel. Reflection factors from 83 to 89 per cent are possible with this finish which is also very hard and flexible. It is also both acid- and alkali-resistant.

The S2S board does not fulfill the requirements of the Underwriters' Laboratory as regards flameproofing. For the duration of the war, however, it is expected that where the fiberboard forms one wall of the wiring channel (the bottom), it will be covered with a light-gauge strip of metal and that this will be acceptable. If the entire elimination of steel becomes imminent for fluorescent fixtures, sheet Transite will become a possibility. This is another material familiar to electrical engineers. The manufacturers of the material discourage the idea of forming into channels on account of the time, expense, and priority requirements of the steel dies involved. The URC has made up wiring channels from flat Transite sheet. This is illustrated in Figure 6. The component parts are fastened together using number three flat-head steel wood-screws which cut their own thread. The result is a very neat and workmanlike job. This method of fabrication is one familiar to utility men for oil-switch and pothead barriers.

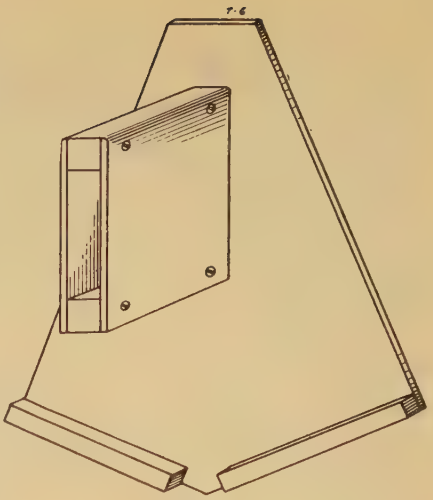


Figure 6. Wiring channel made from flat Transite sheet

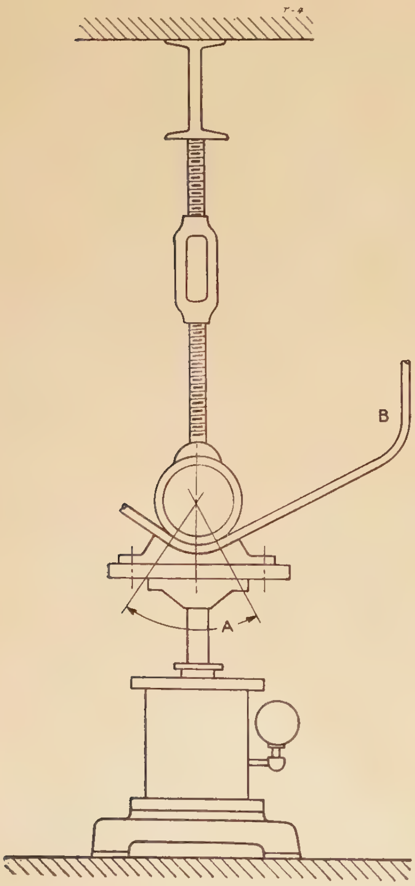
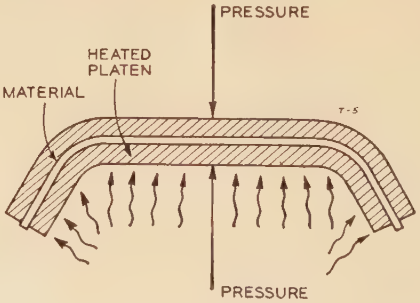


Figure 4 (left). A common method of forming fiberboard between a stationary pipe and a concave platen

Figure 5 (below). A press for forming fluorescent lighting reflectors with platens covering entire surface of reflector sheet



The finished reflectors have the appearance of steel and the uninitiated would not observe any difference. It is probable that after the war the use of the substitute will be continued. For large light-hoods, if made of steel, a very heavy gauge is necessary, since when subjected to sudden impact, the steel acquires a permanent crease or deformation which is almost impossible to remove. With fiber this does not occur. The material is highly resilient and very light in weight compared with the steel which it would normally replace. The price is comparable with steel under normal business conditions.

CONCLUSION

There still remains the steel and copper in the fluorescent ballasts and fixture wire. So far as the fixture wire itself is concerned, the amperage for fluorescent fixtures is quite small and in a portion of it, namely, the starter leads, the current is only momentary, so that there has been some experiment with iron wire insulated with plastic sleeving. At present, ballasts without iron and copper do not appear feasible, but it should be remembered that it is extremely difficult, if not impossible, to attain the intensities and quality of light required in war plants with incandescent lamps using the existing circuit capacity. To attain the same results with incandescent lamps undoubtedly involves more iron and copper than are contained in the fluorescent ballasts, or more than would be obtainable under war conditions.

Electrical Concepts at Extremely High Frequencies

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Some of the characteristics of electricity when the frequency of alternation reaches the range of billions of cycles per second are discussed in relation to the physical pictures of basic electrical concepts, such as current flow along conductors, in tubes, and in circuits which are being evolved by engineers in the high-frequency field. As applied to high-frequency phenomena, some of these concepts now are being modified or broadened in order that more accurate pictures may be obtained.

WHEN such fundamental concepts as current and voltage and circuit are to be examined, it should not be concluded that these notions will shortly be tested and liquidated as not applying to the ultrahigh frequencies. But it is admitted that many of these concepts are, generally speaking, carry-overs from static or low-frequency phenomena and that it is "fitting and proper," as well as good engineering, to stop and make certain that our ideas of electricity are broadened and enhanced by our knowledge of what electricity is at the lower frequencies—broadened and enhanced but not handicapped. It is very easy to paint too crude, unsatisfactory pictures of short-wave-length electricity, if we are to limit ourselves to painting with a huge brush intended for long-wave-length pictures.

For support of this point of view, let us look for a moment at one of the most descriptive diagrams (Figure 1) the physicists have yet given us: a plot of the spectrum of electromagnetic phenomena, frequency and wave length of electromagnetic radiation from the power frequencies, through the radio bands for ordinary broadcast radio, frequency modulation, television, past the ultrahighs, and out of the region we call radio waves and into that we call heat waves or rays; then light rays, visible and ultraviolet, and off into electron beams or cathode rays, X-rays, and cosmic rays. All are electromagnetic phenomena, cousins differing in at least one basic way: frequency or wave length, frequencies from a few to well over a few trillion alternations per second, wave lengths from over a billion meters to a billionth of a meter.

Now, the part of the spectrum with which we are presently concerned is in the range of wave lengths described in centimeters or in the range of frequencies described in billions of cycles per second—a region which, except for Hertz' brilliant impudence in producing sparks near there as the first experiment in radio, long before the intervening region had been gone over at all, we have reached by advancing steadily upward in frequency from the left. Notice how far the centimeter-wave region is from the power frequencies and how appreciably close it is to the heat region and even the light region. In fact, the distance to the ordinary radiobroadcast bands and to the heat and light waves is of the same order of magnitude. As one looks at this diagram, he cannot help wondering how far we can continue to go towards higher frequencies before we cease talking about those ultrahigh frequencies as radio waves and start calling them heat or light waves. Better yet, perhaps some new name is needed to show that these waves are separated from radiobroadcast and heat waves just as heat is separated from light. Also it might be expected that if concepts to help in understanding and describing these centimeter waves were going to be borrowed, they would be borrowed from the waves that are shorter as well as those that are longer.

Suppose we had previously worked with light and heat waves exclusively and gradually found means to make those waves longer until we found ourselves, let us imagine, into the really long wave lengths at the extreme left. In light one speaks about the index of refraction, prisms, and lenses and in heat one thinks about the temperature of the source, and black-body radiation. Suppose we had to wait to have it occur to us that such things as motors and power lines and broadcasting stations might be practical realizations, with our thinking governed entirely by concepts like focal length, virtual images, probably some low-frequency extension of Plank's Radiation Law, and a definition of entropy.

Actually the situation is not so radically different in the centimeter-wave region as this exaggerated reasoning might lead one to believe. There are many concepts which need modification when electricity alternates at extremely high frequencies, but in most cases the reason why they need modification is because they were too narrow in the first place. If the broader concept is used, it usually covers the whole frequency range. At the lower frequencies the broad concepts may appear clumsy and so we are satisfied with the narrow ones;

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but, if we fail to broaden the base, we may find our physical pictures inadequate, if not entirely erroneous and misleading when applied to the ultrahigh frequencies. With this viewpoint in mind, a description of the presently developing physical pictures of electrical concepts in the centimeter-wave region will be attempted.

CURRENT FLOW IN CONDUCTORS

Current flow in conductors, perhaps the most fundamental of all concepts in electrical engineering, is pictured in as simple a fashion by the microwave engineer as by one who works exclusively with direct current, but the role of conductor-current flow in an electrical system undergoes significant changes. Skin effect reaches its ultimate in the centimeter-wave region and currents are no longer thought of as flowing in, or being contained in conductors. Currents and charges flow and rest on conductor surfaces or at least they come so close to doing so that conductor-current flow becomes a surface phenomenon.

Now this has a very important effect upon the engineer's thinking. Almost the first thing one wants to know about centimeter waves is where they are. If nothing really goes on inside conductors, if only conductor surfaces take part in the action, then the conductors become simply boundaries enclosing regions in which the centimeter waves really do their propagating and existing. This does not mean that the current concept has less meaning or is less useful; it is only that conductor-current flow must now more often share the limelight in a problem with electric and magnetic fields. This tends to make electric effects in the centimeter-wave region ally closely with light waves which we usually consider as passing through a medium with the boundaries being either reflectors or absorbers, but definitely the boundaries of the problem, not the central core. Light, we ordinarily think of as a phenomenon that takes place in a medium which will transmit light, not as something that takes place along mirrors or along other boundary surfaces.

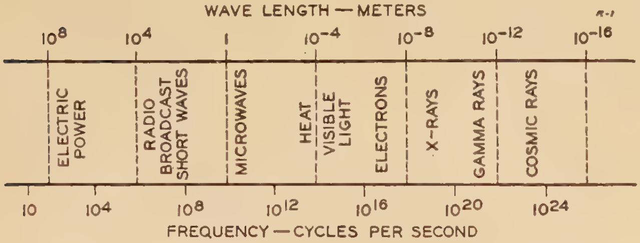


Figure 1. The spectrum of electromagnetic phenomena

CURRENT FLOW IN VACUUM TUBES

It may seem irrelevant to consider concepts that have to do with a device, such as an electron tube, but it is of prime importance to appreciate not only that the electron tube is the machinery of the centimeter-wave engineer, but that tubes and circuits are so closely interrelated that any concept of current flow is poor unless it correctly pictures centimeter-wave current flow from conductors into electron beams and back into conductors again.

Perhaps the most important piece of concept broadening that applies to current flow in vacuum tubes at ultrahigh frequencies is the rejection of the notion, usually satisfactory for the lower frequencies, that instantaneous current flow between electrodes results from the instantaneous arrival of electrons to one electrode, the electrons having come from the other electrode with no time required for transit. With this picture, an electrode takes no current unless it collects electrons. A negatively biased electrode would thus take no current at any instant, if it collects no electrons.

A safe and correct viewpoint is to consider the current in an electron tube as arising from induction in the external circuit because of the presence and motion of charges in the space between electrodes. The time when the electron is finally collected is not the time when current flows; as a matter of fact, that is the time when current due to that electron ceases to flow. When the electron is almost at the electrode, it is so close to that electrode compared to its distance to others, that that close conductor will have received almost all of the lines of electric field flux emanating from the electron. Whatever charge had to come up through the external circuit to furnish an equal but opposite charge on the electrode, has reached its maximum value; when the electron lands on the electrode it neutralizes that charge and completes the picture.

If there is a continuous stream of electrons coming from, say, a cathode to an anode, then, as each electron moves across, it transfers the matching electric charge, present on the face of the electrodes, from the cathode to the anode through the external circuit. A continuous process, a steady flow of electrons, means then that the current flowing in the circuit is equal to the number of electrons arriving per second at the plate times the electronic charge. In this case, the two concepts agree: Current flow in a vacuum tube may be regarded as due to the instantaneous arrival density of electrons to the electrode, or it may be regarded as a movement through the external circuit of the induced charges on the electrode, occasioned by the electrons' presence and motion. Whichever way one looks at it, one gets the same answer. But in the absence of this regularity, there is nothing in the rules that says that the number of electrons leaving the cathode at any instant must equal the number of electrons arriving at the plate at that same instant. Particularly is this so if the frequency is so high that the time taken by electrons to move across is comparable with the time for a complete electrical cycle.

The centimeter-wave engineer, when he thinks of current flow through an electron tube, cannot overlook the fact that that current flow is due to a motion of charges, and that it is an integrated effect of all the induced current due to all the charges with which he must deal. The chief tool, the chief machine of the engineer in the centimeter-wave region, the vacuum tube, is not universally looked upon as a switch or an impedance which can be varied by variation of the various biasing voltages on the electrodes. Instead, the centimeter-wave engineer finds himself thinking about electron paths, electron velocities, transit time and induced currents, and movements of waves of space charge.

CIRCUITS

It may be said that circuits in the usual sense—current around a loop constant in magnitude and phase, instantaneous propagation of the fields due to the currents and charges—rarely are to be found at frequencies of billions of cycles per second. In a few centimeters, a distance comparable to wave length, the current will likely have changed enough to reverse. Many circuits are big enough to have one or more reversals of current around the circuit path and that means piling up of charges periodically along the length of the circuit. All in all, it is better to look at the circuits as transmission lines.

Because the circuits are large compared with the wave length, the amount of energy is proportionately large that refuses to be guided by the conductors to dissipate itself within the system, but prefers to continue on through space on its own, without benefit of guidance by the conductors when it has felt the freedom of propagating as transmission-line waves for a certain distance. A major problem of the centimeter-wave engineer in many of the systems which he designs is to minimize that radiation. The centimeter-wave engineer, in other words, has a problem in insulation. Here we see centimeter waves acting a good deal like heat as well as light.

If radiation is so extreme, if the leakage of energy of centimeter waves from these circuits is so high, then how do we design circuits at these frequencies so as to contain the energy? The answer is found in the fact that centimeter waves will not penetrate metal. If one builds a circuit, it should be built so that the current flow around that circuit is self-enclosing. Figure 2 shows what is meant. Here we see a capacitance shunted by an inductance, an example of the most common impedance in radio engineering, a parallel-tuned circuit, the inductance tuning the capacitance to resonance and yielding a very high impedance. We still need high impedances in the centimeter-wave frequency band but we want no uncalled-for radiation. So, we take again two plates for the capacitance, closing those plates first by a one-turn inductance. Then, to make it self-shielding, we apply more one-turn inductances all around the capacitance plates and the completely closed box results. One may think of the walls as made up of many small cross-section inductance bands in parallel. The capacitance, consisting of the two plates, is closed by the surface on which current flows and it is closed all the way around. All electromagnetic effects, all manifestations of the presence of centimeter waves are confined, practically speaking, to the inside of the completely closed cavity.

These resonant cavities are used as filters, input and output impedances of tubes, and, in general, may be said to be as common in the microwave region as the simple lumped-resonant circuits are in the broadcast band. It can readily be appreciated then that the picture of a circuit which the microwave engineer comes to have includes as paramount features such considerations as the various modes of current and electric- and magnetic-field distributions inside of closed regions, and the dimensions of those cavities with respect to wave length. Just as much as the power engineer finds his thoughts of circuits filled with wye and delta connections, so the centimeter-wave engineer thinks of standing-wave patterns in enclosed regions.

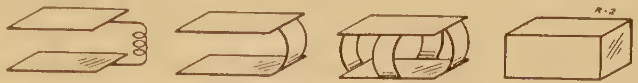


Figure 2. A capacitance shunted by an inductance

VOLTAGE DIFFERENCES

The notion that a conductor is always an equipotential surface, true for electrostatics, is of course totally inapplicable as a general law at frequencies for which currents, charges, and fields actually reverse themselves in a space difference measured in centimeters. For two points on a piece of metal a very short distance apart, it might seem that this law is still valid. But this is not always the case. The common use of self-enclosing conducting systems, such as resonant cavities, very often brings about circumstances in which this persistent but erroneous concept is difficult to reject when one's ideas of voltage difference have become inbred at the lower frequencies. Since centimeter waves will fail to penetrate metal to any appreciable degree, it often happens that very high currents flow on one side of a thin piece of metal, thin compared to wave length but thick compared to the depth of penetration of the current, with resulting high fields and charges in the metal's vicinity on that side, while on the other side, the region is field-free and the surface is free from charges and currents.

For example, the box of Figure 2, if stimulated by a generator on the inside, which charges the top and bottom of the box against each other with accompanying high electric field vertically down the center of the box, may be said with care to possess a voltage difference between top and bottom, where the voltage difference is defined as the integral of the field strength. But an observer, even a very conscientious one, seeking to measure that voltage difference between top and bottom from outside the box, will obtain no appreciable reading if the metal of the box has any appreciable thickness. The inside and outside of the metal in this particular case cannot be properly regarded, in other words, as at the "same potential" even though the thickness of the metal is very small compared to wave length. Centimeter-wave engineers, although accustomed to making good use of the conventional notions of voltage difference, are becoming equally accustomed to regarding the practical inability of centimeter waves to penetrate metal, a more fundamental concept as a guide to proper use of the less fundamental conventional voltage-difference concept.

TRANSMISSION LINES

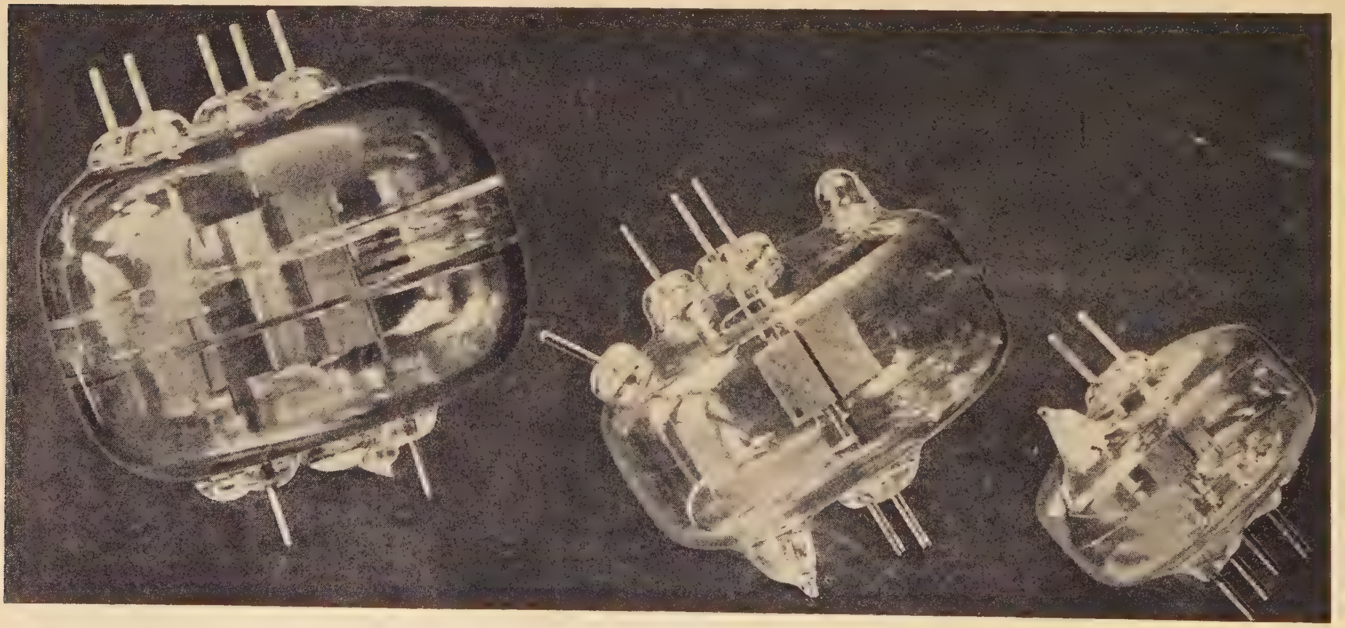
Radiation loss possibilities exercise the same controlling action on the choice of transmission lines for centimeter-wave guiding as they do on the choice of circuits. A practical transmission line to the centimeter-wave engineer usually means a self-enclosing system. A coaxial line is one example. A more interesting type of transmission system that is a better example of how centimeter-wave work is expanding our ideas is the so-called wave guide. This term usually implies a single hollow conductor down the inside of which the energy flows. To the microwave engineer, it represents a practical means of guided-energy transmission which, for its understanding and design, requires emphasis upon the relation between cross-sectional dimensions and wave length not previously a factor of much importance in the transmission line picture. If the frequency is slightly below a certain value, any given hollow tube will very highly attenuate the waves passing down it; if slightly higher than the critical value, the wave guide will become a relatively low-loss transmission system.

RADIATION

With wave lengths in the centimeter range, it becomes possible to borrow concepts from light and sound and as with light and sound to attain beaming effects with reflectors and horns. There is no true broadening of concept here; it is simply that these devices work best if the number of wave lengths across the opening of the horn is high, and such a condition would require enormously large structures at the lower frequencies.

Of greater interest is something that is taking place in the centimeter-wave engineer's pictures of the electromagnetics underlying circuits, transmission lines, and radiators as a result, no doubt, of the greater role radiation plays in the two former classes of electrical systems. It is being appreciated that the radiation of electromagnetic energy is not an entirely distinct phenomenon from the guiding of such energy around a circuit or along a transmission line.

All three classes are properly being thought of as guides of a sort, manifestations of the same phenomena, differing only in the relative magnitudes of their common characteristics. If the conducting and dielectric boundaries are so situated around the source that the energy is mainly contained and dissipated in a relatively small region, then the system is usually thought of as a circuit. If the boundary shapes are such that the energy is guided along a somewhat longer path and absorbed or reflected at the termination with, again, the losses to the surroundings relatively small, then it is probably best termed a transmission-line system, or guide. If the boundaries are such as to draw the energy out of the source and encourage it to continue on through free space with little or no further guidance and with relatively little reflected back to the source, then it is an efficient radiator or antenna.



Experimental vacuum tubes developed by Bell Telephone Laboratories to extend the frequency range of the negative-grid type tube. The smallest, about $1^3/_4$ inches in diameter, can be used as an oscillator at wave lengths as short as 16 centimeters

The Engineer and the Engineering Method

ANATOLE R. GRUEHR
MEMBER AIEE

DOCTOR Charles Felton Scott, a leading engineer and educator of our time, and a past president of the Institute, once expressed the difficulty of defining the term "engineer" as follows: "Our profession is not fixed; it is changing. Even 'the engineer' is an enigma. The learned director of Engineering Societies' Library told me that after spending hours trying in vain to define the engineer he took solace in agreeing with an English friend, 'an engineer is one who can draw sufficient conclusions from insufficient data.' "[1]

At the centennial celebration in 1924 of the Rensselaer Polytechnic Institute, "the first school now in existence which was established in any English-speaking country primarily for the purpose of teaching science and engineering"[2] several speakers indicated what, in their opinions, were the distinguishing characteristics of the engineer. Some of these statements follow.

In a time when values need to be clearly defined, the expressions of several eminent engineers on the distinguishing characteristics of the profession are here presented and analyzed.

"This body of men whose work has been the application of the sciences to the control of force and the production of definite things are men who must from the nature of things be trained in precision of thought. To them every step is the quantitative valuation of forces and materials"—Herbert Clark Hoover, then Secretary of Commerce.[2]

"The modern engineer should be less a technician than a man of broad general training, less an expert mechanic, or electrician, or miner, or what not, and more a man thoroughly grounded in pure science, with especial ability to face new problems and to prosecute original investigation"—James Rowland Angell, president of Yale University.[2]

"In the practice of his profession the engineer cannot always be content with the scientific data at his disposal. He must often take the initiative in its production, working in conjunction with the expert mathematician, physicist, chemist, geologist, and even the biologist. To know when and how to utilize the services of experts, scientific or otherwise, is one of the things that should not be overlooked in technical training.

"If the desired material is not available, the possibility of its production must be considered. To know these materials, their characteristics, and how to use them, how to co-operate with experts in the production of a material for a definite purpose, is another essential that must receive earlier attention.

"The engineer or technologist must assume responsibility and guarantee results more than other professional men. The results of his work can generally be measured or tested. Therefore, the things that develop courage in taking responsibility and getting at the facts of a case must be emphasized in his training. He should look at every task with an open mind, with a view to securing information that will enable him, or someone else, to do it better in the future, a producer of knowledge, not alone a consumer, a leader as well as a follower in his profession"—Samuel Wesley Stratton, president of Massachussetts Institute of Technology.[2]

"Canals, bridges, water works, irrigation systems, great architectural structures were built by the ancient Egyptians, Greeks, Romans, Peruvians. The practice of engineering in their day was a matter of practical craft rather than the application of known principles. It is our modern age which has added most to the widening reservoir of known fact and tested theory"—Carl Ewald Grunsky, president of the American Society of Civil Engineers.[2]

The engineer and his profession have been discussed before professional gatherings as well as in the academic world. The chairman of Institution of Electrical Engineers, said in an address delivered at Manchester, England, October 19, 1937: "An engineer is a person who harnesses and utilizes the forces and materials of nature in the service of man. The definition contained in the charter of The Institution of Civil Engineers states that certain persons had formed themselves into a society 'for promoting the acquisition of that species of knowledge which constitutes the profession of civil engineering, being the art of directing the great sources of power in nature for the use and convenience of man.' He must, therefore, be not only a discoverer but also in a sense a craftsman. He combines some of the functions of the scientist with the skill of the mechanician. It is his task to discover the workings of nature and to apply that knowledge to the satisfaction of human desires and the increase of the amenities of life. In a sense he has one foot in the academic world and the other in the world of affairs. He must know not only what is theoretically possible but also what is commercially and economically practicable. He must have close contact with inanimate materials and also with human beings and be capable of co-operation with them."[3]

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The author wishes to express his appreciation to Doctor Eugene W. Pike for help in discussing and formulating this article.

A. M. MacCutcheon, vice-president in charge of engineering, Reliance Electric and Manufacturing Company, Cleveland, Ohio, and AIEE past president, in an address on the selection and training of engineers, delivered before many AIEE Sections, said: "A clear, concise, definite, and comprehensive conception of an engineer is essential. The dictionary definition—'one versed in or practicing any branch of engineering'—does not meet the requirements. Of the definitions submitted, the following was the best: 'An engineer is one who through training, study, and practice successfully adapts and controls the materials and forces of nature to the benefit and advantage of himself, his fellow engineers, and the rest of the human family.' "[4]

Doctor William F. Durand, chairman and later president of the Third World Power Conference held in Washington, D. C., in September 1936, stated in an address delivered before that conference: "The engineer has been defined as one who is concerned with the utilization of the materials and the energies of nature in the service of man. Amplifying, in terms which define his field of activity and which stand in the preamble to the constitution of American Engineering Council: 'Engineering is the science of controlling the forces and of utilizing the materials of nature for the benefit of man, and the art of organizing and directing human activities in connection therewith.' "[5]

Doctor Scott, in a speech already referred to, before the convention of the National Council of State Boards of Engineering Examiners, said: "Engineering is the agency for making the discoveries of science of practical use. It has two aspects—the theoretical and the practical. It is concerned on the one hand with new knowledge and getting it into usable form and testing it by experience. On the other hand is its application to practical use."[1]

Thus, the engineer has to deal with "the application of sciences to the control of force and production of definite things." He must be "trained in precision of thought . . . quantitative valuation of forces and materials" . . . "less a technician than a man of broad general training" . . . "a producer of knowledge." The implication is that the engineer is a scientist, not a craftsman. On the other hand, he must be "not only a discoverer but also in a sense a craftsman," with "one foot in the academic world and the other in the world of affairs." He has a background of "training, study, and practice." His field of activity is described as "the *science* of controlling the forces and of utilizing the materials of nature . . . and the *art* of organizing and directing human activities." His work "has two aspects—the theoretical and practical," and "is concerned with new knowledge . . . getting it into usable form . . . testing it . . . its application to practical use."

The engineer, then, may be defined as a craftsman and a scientist, an economist and an executive. How does he proceed in performing his tasks? Probably the best general description and definition of "engineering method" is given by Gano Dunn, an eminent engineer and Institute past president, president of J. G. White Engineering Corporation, and also president of Cooper Union for Advancement of Science and Art, in the commencement address delivered at the 70th graduation exercises of the Massachusetts Institute of Technology, Cambridge, June 8, 1937.

"It is not *what* the engineer does, but *how* he does it! Not what the engineer's occupation is, but the intellectual processes by which he attacks that occupation.

"In other words, the *method* of engineers, rather than their *occupation*, is the characteristic of the engineering profession. Method is the common denominator of all engineers. While the subject matter of engineering unquestionably will continue to change in the future, not so with the method of engineering. It is certain that the engineer of the future will be using the present method 150 years hence, even if no prescience is capable of forecasting to what occupations that method will be applied.

"What is this remarkable method that has changed the nature of the world? As is well known, it is the method of science—that process of reasoning based upon observed data and working hypothesis which, by inductive and deductive procedure and experiment, arrives at new knowledge.

"It must be pointed out that, except where their qualities are combined, the engineer and the scientist are not the same person, however much they use the same method. Their objectives are different. Many attempts have been made to define engineering, and engineers do not agree on any one definition; but a definition I worked out some years ago seems to stand the test of criticism and of perspective. It is as follows: *Engineering is the art of the economic application of science to social purposes.*

"Being an art, engineering thrives on repetition. It develops skill and it develops style. The second and third power plants that an engineer builds are likely to be better than the first, although there may not have been introduced a single new principle. The scientist, however, shuts his mind as far as possible to all human prejudice and influence of feeling, save only for the divine fire of that imagination which creates the working hypothesis; and he learns how to discern truth and new knowledge in a study of the order of nature.

"The engineer, by the same intellectual processes as the scientist, applies that new knowledge to social service. The essential difference between the scientist and the engineer lies in the economic involvement of the engineer's work. In this hot crucible of the economic test all that the engineer does must be tried. To repeat an old saying, an engineer is a man who can do with one dollar what any fool can do with two; and it is in his economic involvement that the engineer can rise to some of his greatest powers. . . .

"If the key to the scientist is thought, the key to the engineer is action. Value and utility are the engineer's criteria, rather than truth, which is the criterion of science."[6]

A more specific practical description is offered by Alex D. Bailey, chief operating engineer of the Commonwealth Edison Company, and president of the board of Trustees of Lewis Institute, Chicago, Ill.:

"They brought to the job the ability to analyze the performance of equipment as it had never been done before. They knew how to attack and to solve the technical problems which increased in number and detail. They knew the value of exact information and maintenance of proper records and from these developed exact control of detailed processes; and as a result of this detailed information and the study of operating performance and results, improvements in design were stimulated. Each improvement in turn brought new problems and opened new avenues for further improvements. This was followed by improved control of manufacturing processes with improved products, lower costs, and less arduous labor on the part of the personnel."[7]

According to Doctor Dunn, the engineering method is a method of science. Yet "engineering is the *art* of economic application of science to social purposes." But can the use of methods of science, subject to economic considerations, be regarded as an art? How is this art distinguished from applied science? Is there not a fundamental distinction between the methods of pure and applied science, and the engineering method?

Such distinction seems indicated in the description of the engineer's work as given by Mr. Bailey. It can be clarified if the underlying processes of the scientific and of the engineering endeavor are grouped under two headings:

1. The choice or assignment of problem
2. The method of solution

Pure science has a free choice of any problem in human experience. Its method of approach consists of the analysis of the particular phenomena involved and of their relationships, followed by the synthesis of the similarities into generalizations, or predictions of future behavior.[8]

Engineering, on the other hand, has to deal with problems which are assigned to it and strictly circumscribed. The engineering approach begins with the analysis of the problem in terms of applicable scientific generalizations. Pure science supplies to engineering the generalizations in terms of which this analysis must be made; engineering may depend upon science for a critical evaluation of their application. This critical evaluation may lead to the development of new generalizations useful in further analysis. The engineering analysis in general scientific terms is followed by the process of synthesis of the particular solution into which must enter economic and social considerations as well as scientific considerations. While the scientific analysis and synthesis lead from the particular to the general, the processes used by engineering lead from the general to the particular. Thus, between science and engineering there appears to be a real inversion of method.

The search for new generalizations required to supply deficiencies uncovered in engineering development constitutes the work of applied science. Thus applied science differs from pure science and resembles engineering in that its choice of problems is not free. Its problems originate from the requirements of the engineering synthesis and are circumscribed by the same economic and social considerations which enter into that synthesis. Applied science differs from engineering and resembles pure science in its method of solution, namely, the synthesis of the generalizations on the basis of the analysis of the particular phenomena.

The economic and social considerations that enter into the engineering synthesis call for a solution in which the elements of cost—labor, capital equipment, space, and time—are so proportioned as to approach the marginal utilization of each. For instance, under a social order in which the value of labor is high in relation to the other factors, engineering will resort to the standardization of materials which permits mass production of a limited number of stock items in place of individualized production of specially designed units; standardization and simplification of methods which permit the use of unskilled or semiskilled labor in repetitive operations on highly specialized equipment to produce at low cost what only the highest skill could achieve at a much higher cost with the methods of individual production. Where time is of value, it will develop methods and schedules, synchronizing various operations on various parts of the project in a manner to expedite its completion. Where labor is plentiful and cheap, and time is of no essence, the greatest economy in the use of material and space may call for individual design and production of each unit in successive operations. Thus, a given problem, analyzed in terms of the applicable scientific generalizations, will call for different engineering solutions, each of which will appear as a compromise between the requirements of the problem and the given set of economic and social relationships. The process or the method followed in obtaining such a solution can be called the *engineering method.*

The engineering method can be defined as the art of formulating the solution of an assigned specific problem in terms of the most effective compromise between requirements and costs, using the generalizations, methods, devices, and materials which have been developed by scientific research, adapting them to the existing circumstances, and pointing out the direction of further research needed to develop new generalizations, methods, devices, or materials which would help in formulating a better and more economical solution of the problem. This method can be applied to all fields of human endeavor.

Quoting again, this time from President Karl T. Compton of Massachusetts Institute of Technology, "Our engineering philosophy, with its fusion of the scientific method with practical application, is one of the greatest syntheses of the human mind. . . . By the effectiveness of its method, engineering has won field after field, giving us new respect for mind, and greater power over matter and the unknown. . . .

"If the engineer is to bring his influence to bear on broad public questions he must approach them, not with technical arrogance, but with sympathetic understanding. If he is to counsel the people he must gain the confidence of the people, and this confidence is obtained by placing ministry to the public above all other considerations. This concept of ministering to the public welfare, which is the concept underlying the professional attitude, is the remaining principle that needs to be fully synthesized with other elements that have been combined to form the engineering philosophy . . . if we are to be a true profession we must embrace this third dimension of social responsibility and public service."[9]

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Powder Metallurgy

F. C. KELLEY

Modern powder metallurgy has two principal uses: the cheap and efficient mass production of machine parts that do not require high strength, and the creation of alloys with special properties. Both uses are described and the development of the process is reviewed.

THE ART of forming metallic articles from metal powders represents the earliest form of metallurgy. The Egyptians produced iron implements as early as 3000 B.C., long before the development of furnaces for melting purposes. The process at that time consisted of heating the iron-oxide ore in a charcoal fire with the aid of a bellows, to reduce it to metallic sponge iron. While still hot, it was hammered into the desired shape. Photomicrographs of such implements have been taken by H. C. H. Carpenter and J. M. Robertson, whose findings were published in 1930 in the *Journal* of the Iron and Steel Institute, pages 121, 417–48. Some of the implements were quite free from slag inclusions and compared favorably with modern products made by melting.

Long before the discovery of America, the natives of Ecuador used gold and silver, which form a low-melting-point alloy, to bind together particles of platinum. Platinum was produced by powder metallurgy in Europe during the 18th century. Wollaston is credited with being the first to use a press to form powder into a compact before sintering. He kept this part of his process secret until just before his death.

The developments of the last 30 years in powder metallurgy have kept pace with the tremendous accumulation of scientific knowledge that has contributed so much to raising our standards of living during that period. The outstanding contribution in this field was the invention of ductile tungsten by Doctor W. D. Coolidge of the research laboratory of General Electric Company, Schenectady, N. Y. Tungsten, having one of the highest melting points known, could not be melted, cast, and worked, as can iron or steel. There were no furnaces or ceramic materials which could be used in such processes. In Doctor Coolidge's new method, tungstic oxide was reduced in hydrogen to obtain pure tungsten powder. The powder was pressed at room temperature into bars, but after pressing, the bars could not be handled without danger of breaking. They therefore were given a preliminary sinter at about 1300°C after which they were quite strong. They were then given a high-temperature sintering treatment, just below the melting point, in a hydrogen treating bottle where

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Essential substance of a talk delivered before the Engineering Society of Detroit, Detroit, Mich., October 10, 1941.

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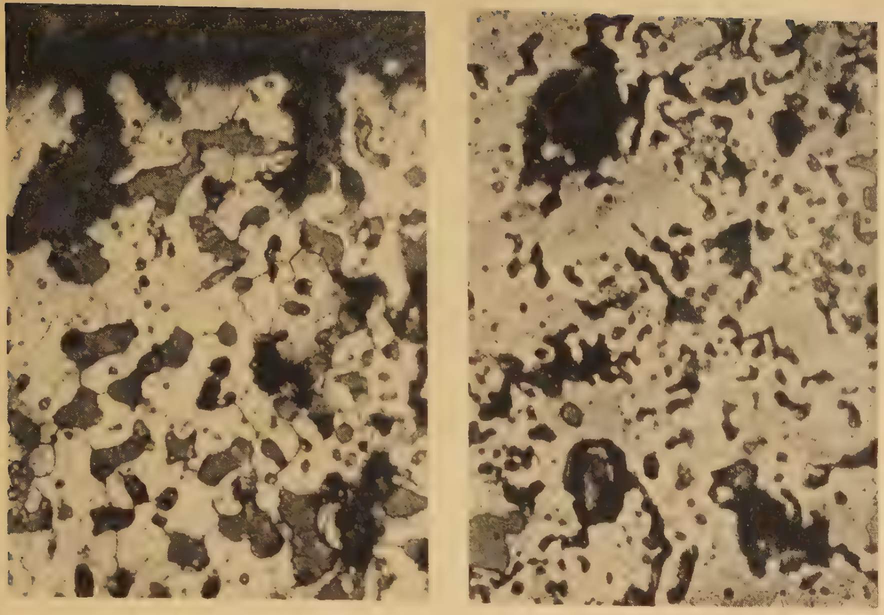


(*a*) (*b*)

Figure 1. Structure in a pinion-gear tooth (a) at the outer edge, parallel to axis; (b) in the body of the tooth

Composition (per cent): carbon 0.08, manganese 0.25, phosphorus 1.39, sulphur 0.024, silicon 0.10, titanium 0.02, vanadium 0.12, aluminum 0.10, nickel nil, remainder iron

Figure 2. Structure of a sample of sintered iron

the current was passed directly through the bar. The sintered bars were then heat-treated in a hydrogen furnace to a white heat, swaged, and finally drawn through diamond dies to be formed into wire. This fine wire was ductile and had great strength. This process is used to make wire for the tungsten-filament lamps now used (see "The Manufacture of Incandescent Mazda Lamps," by James D. Hall, *EE, Dec. '41, p. 574–80*).

The next important development was the invention, by E. C. Gilson of the General Electric research laboratory, of a porous bearing material known as Genelite. It was made from the oxides of copper, tin, and sometimes lead or zinc. The oxides were mixed with graphite and heated in a closed container at a low temperature to allow almost complete reduction of the oxides by the graphite, then screened, and pressed into the desired shapes. These compacts were then packed in charcoal to exclude air, and reheated to about 650 degrees centigrade until reduction of the metals was complete and alloying had taken place among them. These sintered compacts were porous, and when used as a bearing material were saturated with oil. They were also used as brushes for electric machines, but for that purpose were not saturated with oil.

A few years later, N. H. Adams of the same laboratory invented the copper-impregnated tungsten material now used so extensively as an electrode for spot and line welding. This material was made by pressing a bar of tungsten at the desired pressure and sintering it at about 1,300 degrees centigrade in hydrogen. The tungsten then was placed in a graphite boat with copper and heated above the melting point of copper. The capillary attraction of the porous tungsten bar resulted in its complete impregnation with copper. This material had high compressive strength at relatively high temperatures and was also a good conductor of heat and electricity.

The next outstanding development was the invention of cemented tungsten carbide by Heinrich Baumhauer and Karl Schroeter of the Osram Lamp Company, Germany, and the appearance of other mixed-carbide tool materials, such as tungsten carbide–tantalum carbide, tungsten carbide–titanium carbide, and tungsten, tantalum, and titanium carbides bound together with a metal of the iron group, usually cobalt. Balke of the Fansteel Company also made tantalum-carbide tools cemented with nickel. The hardness and toughness of cemented tungsten carbide made it outstanding as a tool material for machining cast iron, steel, Bakelite, hard rubber, and many other materials which cause rapid wear of steel tools.

Several developments in cemented-carbide tool materials of the Carboloy type were made in the General Electric laboratory; namely, hot-pressed cemented carbide, cemented tungsten carbide with substantial amounts of tantalum carbide, and diamond-impregnated cemented carbide for oil-well drills and wheel dressers.

Sintered Alnico, developed by Goodwin H. Howe of the General Electric Research Laboratory, is one of the most recent permanent magnetic materials. It generally is made from aluminum, nickel, cobalt, and iron. Cast Alnico develops a large grain structure, is brittle, and has low impact resistance, but the fine-grained sintered material is strong and has a relatively high resistance to shock.

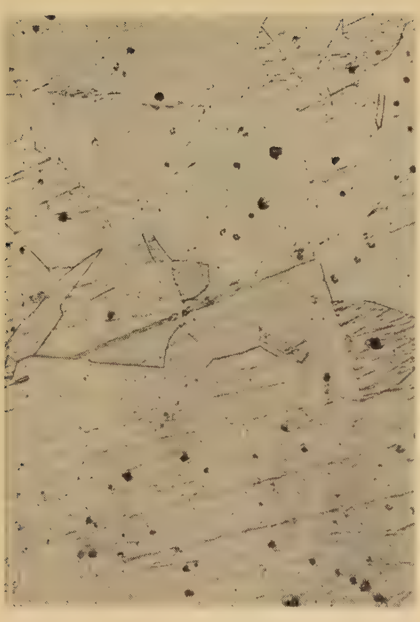
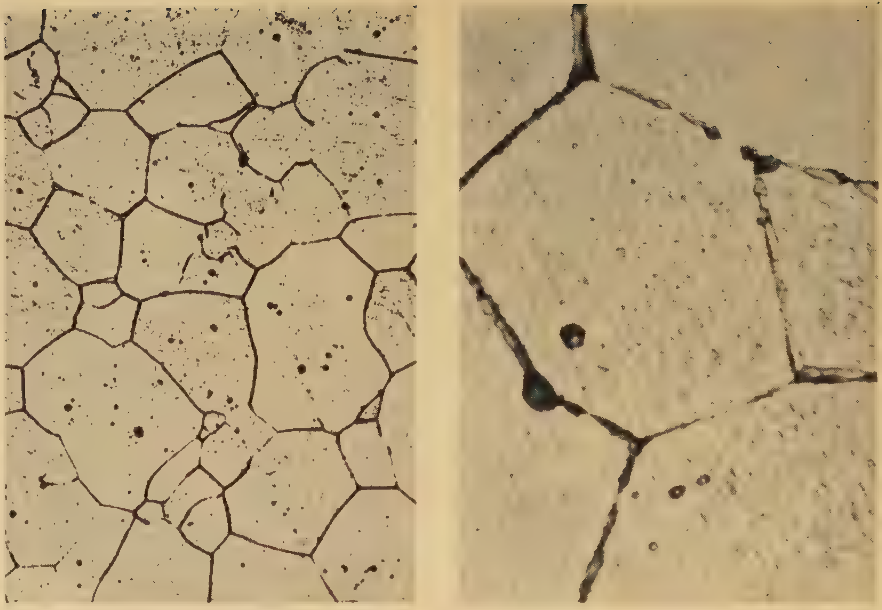


Figure 3. Structure of sintered electrolytic nickel



(*a*) (*b*)

Figure 4. Sintered nickel made from hydrogen-reduced nickel oxide: (a) showing equiaxed grain structure; (b) at 1,000 magnification, showing precipitate along grain boundaries

Research in the field of powder metallurgy, aimed at reducing costs through the utilization of cheaper materials and the elimination of scrap, has brought about another period of development, this time, on a larger scale. New discoveries may make possible sufficient improvement of certain physical characteristics of a material to justify increased original cost, since longer life, improvement of performance, and other gains result in a final saving.

The automotive industry has used oil-impregnated bronze bearings for years, but more recently Moraine Products and Amplex have produced bearings from sintered-iron compositions. They have also extended their application of these materials to the production of oil-pump gears, door catches, cams, filters, and other devices. The automotive industry is ideal for the application of powder metallurgy, since its product has many small parts that require lubrication. Oil-impregnated bearings can be turned out by automatic machines by the million, sintered in atmosphere-controlled continuous-operating automatic-temperature-controlled furnaces where the raw material goes into one end and the bearing comes out the other, finished except for the oil impregnation. In many cases where tolerances are close, however, a cold-coining operation is required; that is, a resizing by restriking the sintered product in a die, or a final sizing by finish-grinding or machining.

Iron parts to which carbon or graphite have been added may be sintered by a temperature sufficiently high to bring about diffusion of the carbon or graphite into the iron, thus forming steel. Iron may be bound together with copper in the same manner. The parts containing carbon may be heat-treated in the same way as are steel articles made from fused metal that has been cast and worked.

Many applications do not require material with high physical properties, but only lubrication to prevent wear. Some ores from which iron powder is made contain impurities, such as silicates and high phosphorus, which enhance the wear-resisting characteristics. The porosity of the compressed compact is controlled by the amount of pressure applied and the temperature and time of sintering.

One of the outstanding pieces of work in this field is that done on hot-pressed brake drums at Chevrolet Wheel and Axle Company, where steel scrap was made sufficiently fine by grinding that it could be cold-pressed, sintered, and then reheated and hot-pressed into a die. These drums have been tested in actual service and found to be as good as or better than those formed from wrought material. The development of this process naturally depends upon the cost of putting the scrap into such condition that it can be easily formed in a die.

The limitations of the process of powder metallurgy naturally depend upon the availability and cost of material. The material commonly used was Swedish sponge iron, because of its high quality and low cost. That source has now been cut off, but there are many firms in America making powdered iron which can be used for this production if the cost can be reduced to, say, five to ten cents per pound. If the demand for this material is great enough, there seems now to be no question about being able to obtain it at a reasonable price.

Powders when pressed do not flow around corners, as do many plastic materials. On that account, the design of the part being formed is very important. The plungers operate in straight lines, and in order to withdraw the plunger or eject the compact after forming without breakage of the compact, the design of the die and compact must be correct.

Many automatic machines of the pill-machine type are being used today to turn out small parts, but as the size of the part increases, the machine-tool cost increases greatly. Since the largest presses are not automatic but hand-operated, the cost of production increases with increase in size. Another difficulty encountered with the increase in size is the nonuniform distribution of pressure throughout the compact, which results in uneven shrinkage if the temperature of sintering is sufficiently high. If the temperature is low, the density is not uniform throughout the compact.

Many of the parts made of present materials are lacking in strength, both tensile and impact, for many applications.

The cost of dies for pressing complicated shapes is high, and unless many thousands are made the cost per piece may be prohibitive.

However, millions of small parts, amounting to tons of material, can be turned out on automatic presses, at very low cost. How else could porous bearings, such as those described, be made so cheaply? Bearings made from solid stock are not self-lubricating, have a relatively high machining cost, and represent a considerable loss of material as scrap. In the case of a gear, this loss may be as much as 75 per cent. The loss of material and the cost of machining are saved by using the powder process.

Intricate shapes may be formed with a single stroke of the press and the size maintained by proper sintering or a cold-coining operation after sintering.

Bearings backed by solid steel and filled with oil do not require high strength, and for many applications require no further lubrication throughout the life of the bearing.

SINTERED MATERIALS

Any discussion of powder metallurgy should include some consideration of the factors influencing sintering, as well as of the physical properties of sintered materials.

Illustrating one class of sintered iron used for bearings and gears, Figure 1a represents the structure found in a pinion gear, taken at the outer edge of the tooth and parallel to the axis. It shows considerable porosity and slag inclusions. Figure 1b represents the structure found in the body of the tooth. There is considerably more porosity, which is characteristic of sintered materials.

The strength of a gear tooth under static and dynamic loading was determined by clamping the gear so that a vertical load could be placed on the tooth tangential to the gear periphery, thus loading the tooth in shear, with the effective area that of the root of the tooth. The breaking load was 1,400 pounds, the equivalent of 10,380 pounds per square inch.

For the impact loading, a 1-pound weight was used. It was first dropped from a height of 4 inches and raised 1 inch at a time until rupture occurred. The tooth broke when the weight was dropped from a height of 10 inches. Since the area of the tooth was 0.135 square inch, the weight required to break the tooth was equivalent to 6.2 foot-pounds per square inch.

Experiments have been made to determine the effects of time, temperature, and pressure upon the density of sintered iron, cobalt, and nickel. The powders used in these experiments were all of high purity. The particle size was −200 mesh, with about 50 per cent −325 mesh.

Table I. Composition of Powders Used in Experiments With Density of Sintered Materials

	Iron	Nickel	Cobalt
Silicon	0.013	0.029	0.075
Iron		0.24	0.19
Hydrogen-sulphide groups		0.19	0.03
Sulphur	0.024	0.025	0.06
Cobalt		0.41	
Nickel			0.31
Manganese	nil	0.004	0.03
Phosphorus	trace	0.007	0.005

Table IIA. Effect of Pressure on Density of Sintered Iron

Temperature 1,425–1,450 degrees centigrade; time 32 hours

Sample	Pressure (PSI)	Density
1	140,000	7.809
2	120,000	7.824
3	100,000	7.830
4	80,000	7.814
5	60,000	7.836
6	40,000	7.816
7	20,000	7.775

Table IIB. Effect of Temperature on Density of Sintered Iron

Pressure 30 tons per square inch; time 32 hours

Sample	Temperature (C)	Density
1	800	6.96
2	1,000	7.08
3	1,200	7.38
4	1,300	7.433
5	1,350	7.45
6	1,400	7.80
7	1,425–1,450	7.725

Table IIC. Effect of Time on Density of Sintered Iron

Temperature 1,425–1,450 degrees centigrade; pressure 30 tons per square inch

Sample	Time (Hours)	Density
1	1	7.5
2	2	7.55
3	4	7.67
4	8	7.658
5	16	7.77
6	32	7.807
7	64	859 7

Table III. Effect of Pressure on Density of Sintered Nickel

Temperature 1,375–1,400 degrees centigrade; time 32 hours

Sample	Pressure (PSI)	Density
1	140,000	8.722
2	120,000	8.787
3	100,000	8.783
4	80,000	8.763
5	60,000	8.725
6	40,000	8.624
7	20,000	8.480

Table IV. Effect of Pressure on Density of Sintered Cobalt

Temperature 1,375 degrees centigrade; time 32 hours

Sample	Pressure (PSI)	Density
1	140,000	8.66
2	120,000	8.66
3	100,000	8.59
4	80,000	8.7
5	60,000	8.71
6	40,000	8.7
7	20,000	8.72
8	10,000	8.69

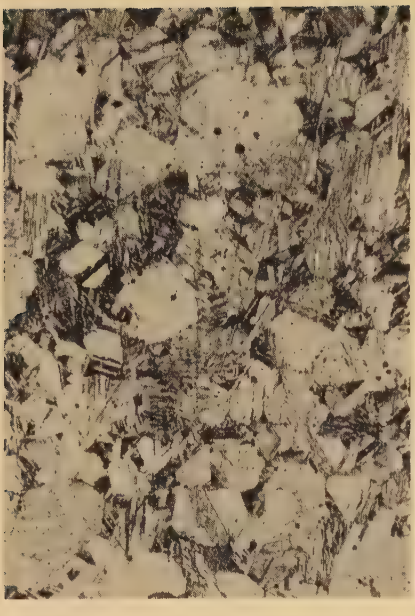


Figure 5. Structure of sintered cobalt

Table I shows the composition of the various powders used. Five-gram samples were used for the tests. They were pressed in a steel mold, using a hand-operated hydraulic press so that the pressure could be obtained very accurately. The size of the bars was $^1/_8$ by $^1/_4$ by $1^1/_4$ inches. This small sample was used to secure pressure as nearly uniform as possible throughout the compact.

Sintered Iron. Seven different pressures were used for the iron samples, and they were all sintered on an iron boat, covered lightly with aluminum oxide (Al_2O_3) to prevent sticking, at 1,425 to 1,450 degrees centigrade for 32 hours in hydrogen. The results given in Table IIA show that at this high temperature of sintering, pressures of 30–60 tons per square inch give the highest densities.

Table IIB shows the effect of temperature of sintering where the pressure was 30 tons per square inch and the time was 32 hours. Between 1,350 and 1,400 degrees centigrade there was a marked increase in density. It seems that 32 hours' sintering is not quite long enough to secure the theoretical density of pure iron, or 7.86.

Table IIC shows the effect of time where the pressure was 30 tons per square inch and the temperature 1,425–1,450 degrees centigrade. For this particular iron, 64 hours were required to secure the theoretical density of 7.86.

From the photomicrograph of this sintered iron (Figure 2) the soundness of the compact and the large grain size developed by the long-time sintering can be observed. The small rounded globules are fused silicates.

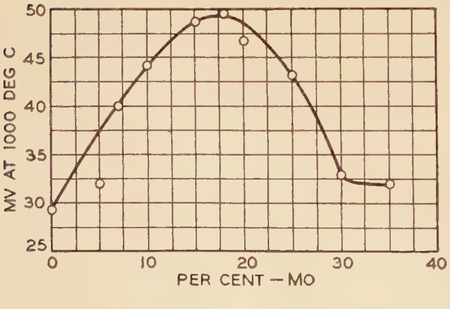


Figure 6. Change in millivolt output with change in composition of nickel-molybdenum-nickel thermocouples

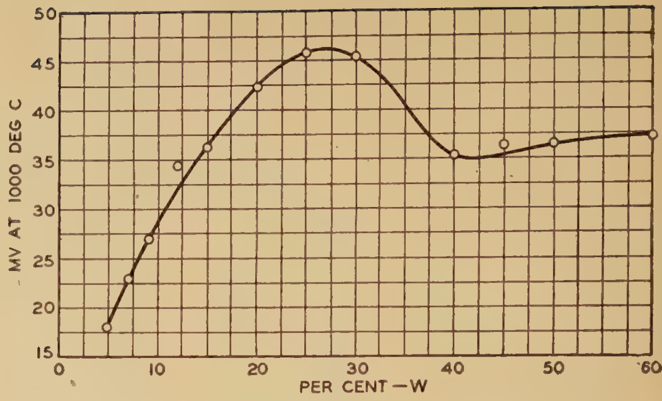


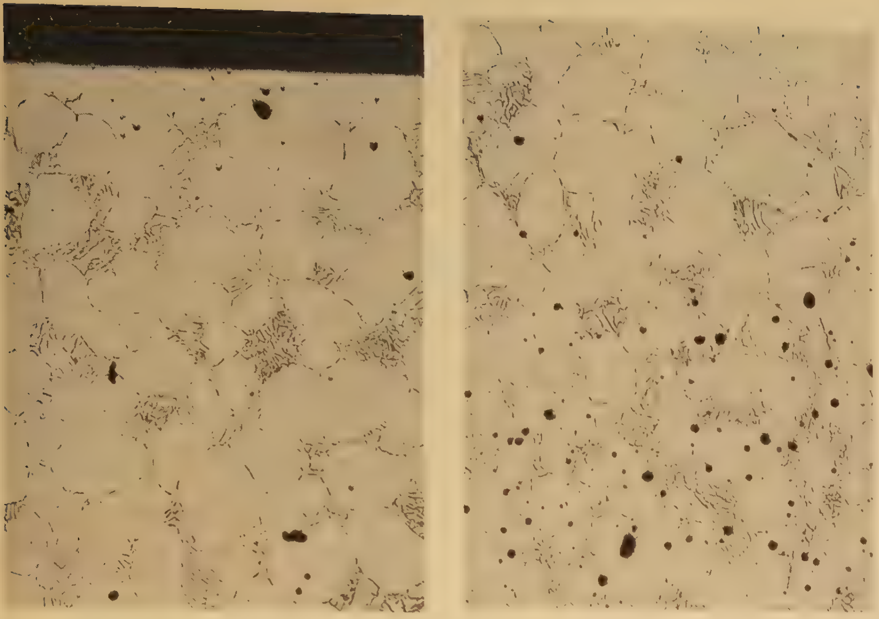
Figure 7. Change in millivolt output with change in composition of nickel-tungsten-nickel thermocouples

Sintered Nickel. A series of nickel samples was pressed and sintered at 1,375–1,400 degrees centigrade for 32 hours in hydrogen. The results are given in Table III. As with iron, the theoretical density—for nickel, 8.9—was not quite reached in 32 hours. The optimum pressure range seems to be 40–60 tons per square inch. The impurities in this nickel may affect its density also. A photomicrograph (Figure 3) of this material, which is electrolytic nickel, shows the sharp angular grains. Nickel made from hydrogen-reduced nickel oxide and sintered in the same way is shown in Figure 4a. The equiaxed grain structure obtained from this powder may be seen. Figure 4b, a photomicrograph taken at 1,000 magnification, shows a precipitate along the grain boundaries.

Sintered Cobalt. Cobalt samples pressed and sintered at 1,375 degrees centigrade for 32 hours in hydrogen give the results shown in Table IV. Again there is an optimum pressure range which gives the highest density. This density comes within the range 8.6–8.9. Pure cobalt exists in two different phases, and the density may vary with the amount of each phase present. Since these samples were all sintered together at the same time under the same conditions and made from the same lot of cobalt, this factor may be eliminated as contributing

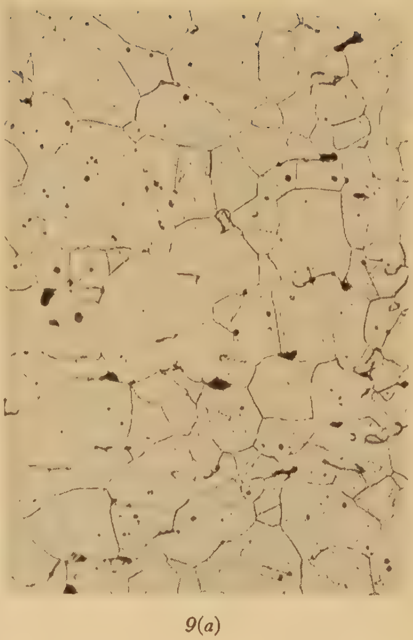
Table V. Results of Sintering "18–8" Stainless Steel

Sample	Particle Size	Per Cent Shrinkage	Rockwell B Hardness	Per Cent Reduction of Area	Per Cent Elongation	Tensile Strength (PSI)	Density
"18–8" Made from Mixed Powders							
A2	−200	25	65–69	30.5	20	79,250 a 25°C	7.64
A24	−200	24.4	67	17.5	24	19,500 a 1,500°F	7.35
A26	−200	21.8		19.5	30	24,500 to 27,500 at 1,500°F after 25 per cent reduction	7.35
Wulff's "18–8" Powder							
1	−100+200	11.5	62	27	21	54,500	7.886
2	−200+325	10.2	64	56	44	58,300	7.8856
3	−325	7.9	66	66.2	45	58,300	7.895

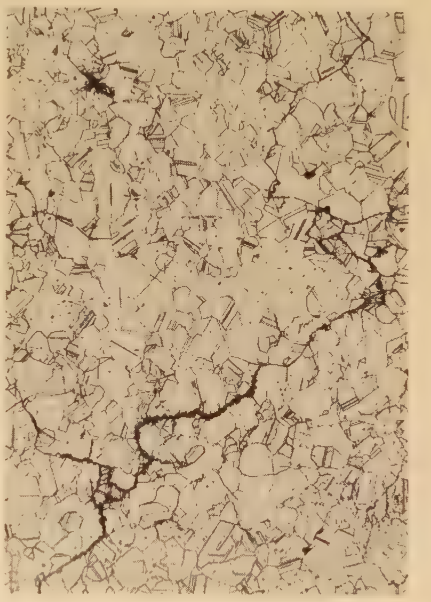


8(a) 8(b)

Figure 8. Structure in sintered bar of Wulff's "18–8" stainless steel: (a) at surface of bar; (b) at center of bar



9(a)



9(b)

Figure 9. Structure of Hastelloy B: (a) after sintering; (b) after sintered sample has been reduced one fourth by hot swaging

to the variation in density. Figure 5 represents the structure of the sintered cobalt.

These results on the sintering of pure metals at temperatures close to their melting points show quite conclusively that sound bars may be obtained from pressed and sintered compacts when sintered for a long enough time. They also indicate that each metal has an optimum pressure at which the highest densities may be obtained. Temperature and time are the most important factors in obtaining sound materials from pressed powders; pressure is the least important. The highest pressures in every case gave densities below those obtained over the optimum pressure range.

ALLOYS FROM METAL POWDERS

The highly specialized and scientific work of Doctor W. P. Sykes of the Cleveland Wire Works, on the binary systems of iron-molybdenum, iron-tungsten, nickel-molybdenum, nickel-tungsten, cobalt-tungsten, and other compounds, has all been done with metal powders. It has furnished a means of obtaining the pure materials so essential for accurate work in powder metallurgy.

Iron-Nickel-Cobalt Alloy. An alloy of iron, nickel, and cobalt has been produced by the sintering process, that has all the physical characteristics of the same material made by melting. The chief characteristic of this alloy is that it follows very closely the expansion coefficient of certain grades of glass and is stable over a wide temperature range, even extending to liquid-air temperatures.

The sintered material has furnished a method for accurately controlling the composition and expansion characteristics, avoiding contamination so often encountered in melting, and eliminating scrap losses. The theorist might say that equilibrium could never be established in such a system. As a matter of fact, we seldom deal with alloys which are in equilibrium, and this alloy is an outstanding example of a material produced from powdered metals which can meet such exacting physical requirements as are demanded of a metal sealed to glass.

Nickel-Molybdenum and Nickel-Tungsten for Thermocouples. The General Electric laboratory has produced nickel-molybdenum and nickel-tungsten alloys by sintering, which, when welded to nickel, produce couples capable of operating in hydrogen furnaces at temperatures up to 1,300 and 1,400 degrees centigrade respectively. Tests on nickel-molybdenum–nickel couples over periods above 3,000 hours at high temperatures have shown that they do not vary more than plus or minus 5 degrees centigrade from the original calibration. No tests of such long periods have been made on the nickel-tungsten–nickel couples, but there is no reason why they should not give equal performance at 1,300 degrees centigrade for an equal length of time. Figure 6 shows the change in millivolt output with the change in composition of the nickel-molybdenum alloy used against nickel at 1,000 degrees centigrade. The same relationship for the nickel-tungsten–nickel couples is shown in Figure 7. These charts show a rather broad peak on the curves, where the millivolt output changes very little with a relatively large change in compositions. These are the compositions selected for duplication of millivolt-temperature characteristics.

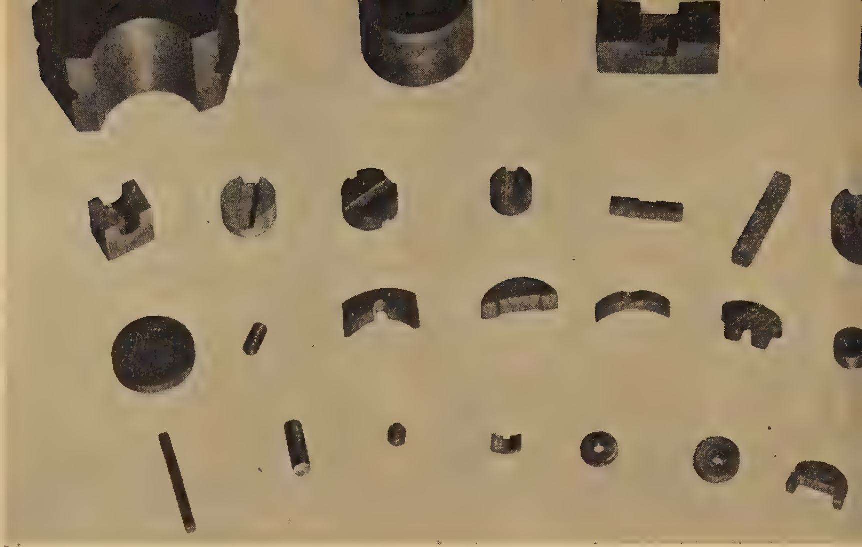


Figure 10. Sintered Alnico magnets of various shapes and sizes

Sintered "18–8" Stainless Steel. The sintering of "18–8" stainless steel (74 per cent iron, 18 per cent chrome, 8 per cent nickel) requires an atmosphere with an extremely low partial pressure of both oxygen and water vapor. Pure hydrogen is one of the best mediums for this purpose. It is made by passing the gas through sulphuric acid, over copper in some form heated 6,000 degrees centigrade, and then over phosphoric pentoxide (P_2O_5). When phosphoric pentoxide is used, the partial pressure of water vapor is so low that chromic sesquioxide (Cr_2O_3) may be reduced by it.

The gas cannot be passed into a commercial furnace and maintain this low partial pressure of water vapor. The sintering must be done in a closed iron tube or some tight container provided with only a small leak for renewal of the pure gas atmosphere.

At the General Electric laboratory we have pressed and sintered "18–8" from mixtures of iron, chromium, and nickel powders, and also from powder furnished by Professor John Wulff of Massachusetts Institute of Technology. The latter powder was made by pickling heat-scrap "18–8" in a solution of sulphuric acid and cupric treated sulphate ($H_2SO_4+CuSO_4$). The carbides are attacked at the grain boundaries, leaving the individual crystals of "18–8" behind. The copper is removed and the powder washed and screened to various sizes.

The results of tests made on the mixed powders pressed at 30 tons per square inch and sintered for 32 hours at 1,375 degrees centigrade are shown in Table V. The percentage shrinkage in volume varied from 20 to 25 per cent. The tensile strength at room temperature was 79,250 pounds per square inch, and at 1,500 degrees Fahrenheit it was 19,500 pounds per square inch.

The elongation and reduction of area were not taken at room temperature, but at 1,500 degrees Fahrenheit the elongation was 27 per cent and the reduction of area 20 per cent.

Figures from the Allegheny Ludlum Steel Company give 80,000 pounds per square inch as the ultimate strength with 55 per cent elongation and 65 per cent reduction of area of annealed "18–8."

Table VI. Results of Sintering Hastelloy

			Sintering									
Sample No.	Particle Size	Pressure (PSI)	Temperature (C)	Time (Hr)	Per Cent Shrinkage	Temperature of Test	Tensile Strength (PSI)	Tensile Strength After 25 Per Cent Reduction	Per Cent Elongation	Per Cent Reduction of Area	Density	Rockwell B Hardness
Hastelloy From Mixture of Hydrogen-Reduced Molybdenum Oxide, Electrolytic Nickel and Electrolytic Iron												
C28	−200	60,000	1.250	24	10.4	1,500 F		86,000	10.8	13.0		
C29					15.3	Room	87,000		20.0	11.95	8.16	68.0
C30					13.9	Room	85,000		21.0	15.4	8.25	72.3
C31					16.5	1,500 F	43,000		8.0	8.0	8.2	70.7
Hastelloy From Mixture of Hydrogen-Reduced Oxides of Molybdenum, Nickel, and Iron												
C32	−325	60,000	1,250	24	45.0	1,500 F		61,000	5.0	5.5		
C33					46.0	Room	98,600		0.013	6.53	9.2	101.8
C34					45.8	Room	96,200		0.013	6.96	9.2	102.8
C35					47.8	1,500 F	44,000		5.0	4.0	9.26	103.0
Effect of Time on Hastelloy B (99.5 Per Cent Molybdenum Trioxide Plus Nickel and Iron Oxides)												
D8		60,000	1,250	2	32.6						8.63	94.3
D9				4	46.9						8.6	92.3
D10				8	46.6						8.83	89.5
D11				16	48.9						8.92	96 5
D12				24	45.8						9.0	96.0

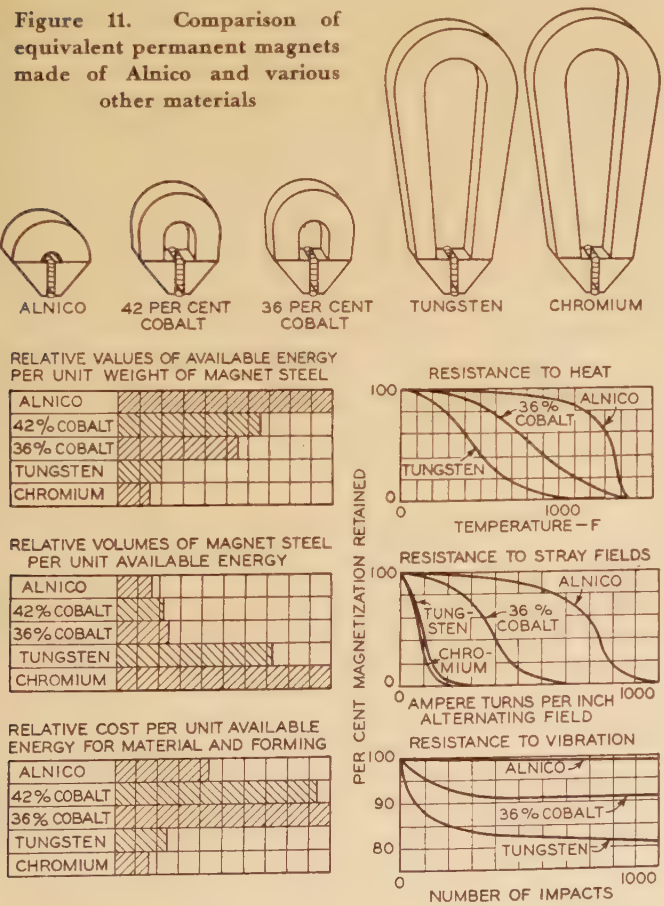
The powder furnished by Professor Wulff did not press very solid at 30 tons per square inch, and the sharp corners of the pressed bars crumbled on handling. Three different particle sizes were used: −100 plus 200, −200 plus 325, and −325. Bars sintered at 1,375 degrees centigrade for 24 hours in pure hydrogen gave the results shown in Table V.

With a decrease in particle size, the percentage shrinkage in volume decreases. This is exactly the reverse of the result usually obtained with iron powders. The elongation and reduction of area increase with the decrease in particle size. The physical characteristics of sample 1, which had the coarsest particle size (−100 plus 200) are definitely lower than those of samples 2 and 3, which show very little difference. The densities are well within the range 7.86–7.925 given by the Allegheny Ludlum Steel Company for this material.

A photomicrograph of a sintered bar of Wulff's material, taken at the surface of the bar, is shown in Figure 8a; Figure 8b shows the same material taken at the center.

Hastelloy B. This material (65 per cent nickel, 28 per cent molybdenum, 7 per cent iron) has relatively high strength at high temperature. It has been made from electrolytic nickel and iron and hydrogen-reduced molybdenum and also from reagent oxides hydrogen-reduced to give the metals. The particle size in the first case of the electrolytic nickel and iron was −200, with 50 per cent −325. In the second case, the particle size of the hydrogen-reduced metals was −325.

Figure 11. Comparison of equivalent permanent magnets made of Alnico and various other materials



The sintering of these materials was carried out in the purest hydrogen at 1,250 degrees centigrade for 24 hours after pressing at 30 tons per square inch. The results, as given in Table VI, are extremely interesting.

There is great difference in shrinkage between the C28–C31 and the C32–C35 groups of samples. The higher hardness of samples C33 to C35 is typical of hydrogen-reduced metals. The greater strength of samples C33 and C34 is to be expected on account of their higher densities and hardness. Yet after 25 per cent reduction by hot swaging, sample C28 shows as high strength at 1,500 degrees Fahrenheit as samples C29 and C30 do at room temperature; and sample C32 after 25 per cent reduction by hot swaging shows less strength at 1,500 degrees Fahrenheit than does either sample C33 or sample C34 at room temperature. There is little difference in the strengths of the as-sintered samples C31 and C35 at 1,500 degrees Fahrenheit.

The effect of time of sintering on shrinkage, density, and hardness is given by samples D8–D12. The greatest part of the shrinkage occurred in the first four hours, but the density and hardness increased steadily with time. Figure 9a represents the structure of sintered Hastelloy B. Figure 9b represents the same material after 25 per cent reduction by hot swaging. The hot-worked specimen shows very little porosity. The crack in this particular sample occurred only at the very end of the rod. The grain refinement caused by hot swaging is very marked.

Sintered Alnico. This material lends itself to mass production of small parts. It may be presintered and formed from stock material where a few parts are needed, without making a mold, but pressing a shape by a single operation, as was done with the many small magnets shown in Figure 10, is much more economical for quality production.

A comparison of Alnico magnets with equivalent permanent magnets made of other materials is shown in Figure 11.

This article has attempted to give briefly a picture of the development of powder metallurgy, with examples of some of its applications. The uses of the process may be classified under two divisions: mass production of machine parts that do not require high strength—such as oil-pump gears, bearings, and others; and production of materials that require some specific physical characteristic—such as ductile tungsten for lamp filaments, cemented carbides for cutting tools, or sintered Alnico for magnets.

While the adequate development of any of the subjects mentioned would require a volume, the author hopes that this article has given those unacquainted with the subject a clearer idea of what powder metallurgy is, and furnished those working in the field with some data on the physical properties of various materials.

INSTITUTE ACTIVITIES

AIEE Board of Directors Meets

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, on August 7, 1942.

Upon recommendation of the standards committee, the board approved for publication as a revised AIEE standard, a revision of AIEE Standard No. 27, "Switchgear Assemblies," submitted by the committee on protective devices.

Recommendations concerning the policies and activities of the Institute under war conditions were submitted by the committee on planning and co-ordination and adopted by the board of directors, as published elsewhere in this issue.

Announcement was made of the appointment by the president of the standing and general committees of the Institute for the administrative year beginning August 1, 1942 (for a complete list of officers and committees for 1942–43, see pages 483–7 of this issue).

As required by the bylaws, the board confirmed the following appointments by the president:

Edison Medal Committee—N. E. Funk, *chairman* for the year 1942–43; F. D. Newbury, D. C. Prince, and W. E. Wickenden *members* for the five-year term beginning August 1, 1942.

T. F. Barton, T. G. LeClair, and K. B. McEachron, elected from the board of directors, *members* for a term of two years beginning August 1, 1942.

Charles LeGeyt Fortescue Fellowship Committee—O. E. Buckley and Ernst Weber *members* for the three-year term beginning August 1, 1942.

Lamme Medal Committee—C. L. Dawes, J. L. Hamilton, and K. B. McEachron *members* for the three-year term beginning August 1, 1942; C. M. Laffoon to serve for the unexpired term, ending July 31, 1943, of R. E. Hellmund, deceased.

As most of the functions of the Institute policy committee come within the scope of the committee on planning and co-ordination as reorganized a few years ago, it was decided to abolish the Institute policy committee, to appoint committees for the consideration of special subjects as occasions arise, and to appoint at this time a special committee on registration of engineers.

Approval was given to dates for District meetings, as follows: North Eastern District, Providence, R. I., April 7–9, 1943; South West District, Kansas City, Mo., April 28–30, 1943.

Representatives of the Institute on other bodies were appointed for the one-year term beginning August 1, 1942. O. W. Eshbach was reappointed a representative on the Engineers' Council for Professional Development for the three-year term beginning in October 1942, and L. W. Chubb was reappointed a representative on the Research Procedure Committee of The Engineering Foundation for the term of one year beginning in October 1942.

The following Local Honorary Secretaries of the Institute were reappointed for the term of two years beginning August 1, 1942:

V. J. F. Brain for Australia
A. S. Garfield for France
V. F. Critchley for Northern India
M. N. Iengar for Southern India
W. Elsdon-Dew for Transvaal

Other matters taken up by the board included the following:

Minutes of the meeting of the board of directors held June 24, 1942, were approved.

A report of a meeting of the board of examiners held July 23, 1942, was presented and the recommendations adopted at that meeting were approved. Upon recommendation of the board of examiners, the following actions were taken: 10 applicants were transferred to the grade of Fellow; 56 applicants were transferred to the grade of Member and 14 were elected to the grade of Member; 96 applicants were elected to the grade of Associate; 169 Students were enrolled.

Expenditures in July amounting to $28,018.72 were reported by the finance committee and approved by the board.

Those present were:

President—H. S. Osborne, New York, N. Y.

Past Presidents—David C. Prince, Schenectady, N. Y.; R. W. Sorensen, Pasadena, Calif.

Vice-Presidents—A. G. Dewars, Minneapolis, Minn.; N. S. Hibshman, Bethlehem, Pa.; J. Elmer Housley, Alcoa, Tenn.; C. R. Jones, New York, N. Y.; K. B. McEachron, Pittsfield, Mass.; C. A. Price, Hamilton, Ont.; E. W. Schilling, Bozeman, Mont.

Directors—T. F. Barton, New York, N. Y.; M. S. Coover, Ames, Iowa; M. Eldredge, Washington, D. C.; C. M. Laffoon, East Pittsburgh, Pa.; T. G. LeClair, Chicago, Ill.; Fred R. Maxwell, Jr., Pensacola, Fla.; F. J. Meyer, Oklahoma City, Okla.; W. B. Morton, Glenside, Pa.; W. R. Smith, Newark, N. J.; R. G. Warner, New Haven, Conn.

National Treasurer—W. I. Slichter, Schenectady, N. Y.

National Secretary—H. H. Henline, New York, N. Y.

Have You Traveled Abroad?

If so,
Government Solicits Your Assistance

A letter recently received by National Secretary H. H. Henline from Acting Secretary of Commerce Wayne C. Taylor states that the Government is in need of any specialized or unusual information that might possibly be supplied by AIEE members who have traveled abroad, concerning the commodities used or produced abroad, and also concerning economic, industrial, and social conditions in foreign countries. Casual tourists are excluded, but all who have gone abroad on business trips, or who have resided for a time in foreign countries are earnestly being sought.

All AIEE members who qualify are urged to write at once to Mr. Taylor, U. S. Department of Commerce, Washington, D. C., so that a Department of Commerce inquiry form may be sent to each such member for the brief recording of information concerning foreign countries and cities that have been visited, periods of foreign residence, and business firms or organizations contacted.

NEW MEMBERS

All Institute Members:

Each one of you will shortly receive a letter asking for the names of associates or acquaintances whom you consider qualified for membership in AIEE. Every member must know at least one such individual. Let us have his name! Talk to him yourself! Take him to the next meeting of your Section so that he can see for himself what the Institute has to offer him personally!

John H Pilkington

Chairman, National Membership Committee

AIEE Participates in Selecting Signal Corps Library

The AIEE committee on co-operation with war agencies has organized a subcommittee to assist the Signal Corps in selecting the nucleus of scientific and technical material for the recently established Signal Corps Reference Library in Washington, D. C. Nationally known engineering societies have pledged their co-operation in making available for this project books and periodicals that would be difficult to obtain through commercial outlets. The field of interest covers electronics, radio, telephone, telegraph, engineering, electricity, meteorology, physics, chemistry, electron microphotography, photography (still and motion), cryptology, signal communication, pidgeon breeding and training, direction-finding equipment, and many other technical subjects. Technical books and pamphlets on these subjects will be welcomed and may be shipped directly to the Signal Corps Reference Library, Office of the Chief Signal Officer, War Department, Washington, D. C. Contributors should make use of the special bookmailing rate of $1^1/_2$ cents per pound, not to exceed 70 pounds in any one package.

Bibliography Published on Electrical Safety

The third bibliography of technical literature entitled "Bibliography on Electrical Safety, 1930–1941" has just been published by the Institute. This publication, sponsored by the AIEE committee on safety, is designed to make available a fund of information on electrical safety which should be of special interest at a time when accident prevention is of national importance. A list of applicable standards, specifications, and safety codes is also included. Information on safety published before 1930 may be located through bibliographies accompanying articles listed.

The items in this bibliography are divided into sections according to subject matter as follows:

A. Electrical Accidents and Their Causes
B. Accident Prevention Methods
C. Safety Codes and Standards
D. Effects of Electric Shock
E. Resuscitation

The "Bibliography on Electrical Safety, 1930–1941" is a 16-page pamphlet, $8^1/_2$ by 11 inches. It may be obtained from AIEE headquarters, 33 West 39th Street, New York, N. Y., at 25 cents per copy to Institute members (50 cents to nonmembers) with a discount of 20 per cent for quantities of 10 or more mailed at one time to one address. Remittances, payable in New York exchange, should accompany orders.

Additional 1941 District Prizes

The 1941 AIEE North West District prize for initial paper was awarded to Waldo E. Enns (A'37) for his paper entitled "Methods and Apparatus for A-C Network Analysis Using Resistance Networks," which was presented at a meeting of the Portland Section held on April 16, 1941. (See page 479 of this issue for biographical sketch.)

The AIEE 1941 Southern District (4) prize for Branch paper was awarded to Joe E. Woodward (A'42) for his paper entitled "The Vectorscope," which was presented at the annual Southern District convention of Student Branches, held at the University of Alabama, April 3–5, 1941. (See page 480 of this issue for biographical sketch.)

AIEE Wartime Policies Defined

Institute policies and activities under war conditions as formulated by the AIEE committee on planning and co-ordination and adopted by the board of directors on August 7, 1942:

National Conventions and District Meetings: The Institute should continue holding National conventions and District meetings, but all programmed social activities should be omitted, including dinner dances, the ladies' program, and those trips which do not form a part of the technical program. National conventions should be called National technical meetings and District meetings should be called District technical meetings.

Section Meetings: Section meetings should be continued, particularly since they require little, if any traveling and involve no publication. Sections are requested to devote their meetings to war activities to the extent that this would be helpful to the war effort but there is no objection to their also holding meetings which do not meet this criterion.

Technical Papers: All solicited technical programs and papers should be closely related to the war effort. A limited number of unsolicited papers which meet other Institute requirements may be accepted for presentation. However, in accepting such papers, preference will be given to those aiding the war effort, and those not meeting this requirement should constitute a minor part of the total program. In submitting papers to the technical program committee for approval, the technical committee sponsoring the paper shall include in the submittal a statement of the relation of the paper to the war effort and of the reasons for recommending its presentation.

Publications: Publications should follow the same policy as technical papers. The publication committee should take the responsibility for insuring that all publications meet the censorship requirements.

Standards Committee: The standards committee is requested to review carefully the possibility of war emergency standards and devote its attention particularly to stimulating the authorization and production of such standards. It would be desirable for the standards committee to review the situation with War Production Board representatives.

Defense Committee: The defense committee is requested to make a constructive review of the relation of the Institute to war activities and suggest additional activities which the Institute could advantageously undertake in aid of the war effort. (The board of directors, on August 7, changed the name of this committee to committee on co-operation with war agencies.)

Committee on Planning and Co-ordination: It is suggested that the committee on planning and co-ordination continuously examine these and other Institute matters to insure that prompt changes are made, if necessary.

Other Committees: Those committees not specifically mentioned should review their plans and formulate programs of committee work in the spirit of the policies outlined above.

Future AIEE Meetings

Pacific Coast Convention
Vancouver, B. C., September 9–11, 1942

Winter Convention
New York, N. Y., January 25–29, 1943

North Eastern District Meeting
Providence, R. I., April 7–9, 1943

South West District Meeting
Kansas City, Mo., April 28–30, 1943

Lamme Medal Nominations

Attention is called again to the opportunity open to any Institute member to submit nominations for the 1942 AIEE Lamme Medal. All nominations must be received not later than December 1. For further particulars see *Electrical Engineering*, June 1942, page 321.

The 1941 medal was awarded to Forrest E. Ricketts, vice-president, Consolidated Gas Electric Light and Power Company, Baltimore, Md. Addresses delivered at the presentation ceremonies were published in *Electrical Engineering*, August 1942, page 396.

STANDARDS • • •

Standards for Switchgear Apparatus

The general adoption of standard basic impulse insulation levels (Table I) has made practicable the analysis of insulation levels of various types of apparatus and the allocation of proper low-frequency and impulse tests for all voltage classes. Such a study of switchgear equipment has been undertaken by the AIEE protective devices committee.

A brief statement covering preliminary work on outdoor circuit breakers appeared in the September 1941 issue of *Electrical Engineering*, page 448. Further work has resulted in agreement by the AIEE protective devices committee and others on the standard test voltages as given herein for indoor and outdoor circuit breakers, disconnecting switches and bus-bar supports, and assembled switchgear. Switchgear apparatus should be capable of withstanding these test voltages without flashover when tested in accordance with the conditions specified in the individual standards for particular types of apparatus.

These test voltages are presented in order to make the information generally available to the industry as quickly as possible. The same data will be included in the corresponding revised AIEE and American Standards as soon as they are published.

The test voltages for indoor and outdoor power circuit breakers (which will be published as part of American Standard *C*37.4) are given in Table II with explanatory notes. Bushings used with circuit breakers should conform with the requirements of the Standard for Apparatus Bushings (AIEE Standard 21). Wet tests are not required on completed outdoor circuit breakers as the wet tests which are required on bushings as design tests serve the purpose adequately.

The values for air switches and bus supports will be published in AIEE Standard 22. Those for outdoor devices are shown with explanatory notes in Table III. For indoor air switches and bus supports it has been agreed to accept for the present the values afforded by standard commercial equipment as shown in Table IV.

The work on insulation levels for fuses

Table I. Basic Impulse Insulation Levels

Reference Class (Kv)	Basic Impulse Level (Kv)
1.2	30
2.5	45
5.0	60
8.7	75
	95
15	110
23	150
34.5	200
46	250
69	350
92	450
115	550
138	650
161	750
196	900
230	1,050
287	1,300
345	1,550

Table II. Standard Insulation Test Voltages. Power Circuit Breakers

		Standard Insulation Tests—Withstand Voltage—Kv			
		Indoor Breakers[a,b]		Outdoor Breakers	
Insulation Class	Range of Interrupting Rating	Low Frequency One Minute (Dry)	Impulse 1.5x40-μsec Full Wave (Pos. or Neg.)	Low Frequency One Minute (Dry)	Impulse 1.5x40-μsec Full Wave (Pos. or Neg.)
2.5	25,000 to 50,000 kva	15	45 ....30[c]	15	45
	Above 50,000 kva	19	60 ....45[c]	19	60
5.0	25,000 kva and above	19	60 ....45[c]	19	60
7.5	25,000 to 150,000 kva	26	75 ....60[c]	26	75
	Above 150,000 kva	36	95 ....75[c]	36	95
15	Air and oil 25,000 to 250,000 kva, also, oil 500,000 kva with 3 phases in one tank, and to comparable air breakers above 250,000 to 500,000 kva	36	95 ....75[c]	50	110
15	Oil breaker rated 500,000 kva and above with each phase in one tank and to comparable air breakers 500,000 kva and above	50	110[d]....95[c]	50	110
23	All interrupting ratings	60	150[d]	60	150
34.5	All interrupting ratings	80	200[d]	80	200
46	All interrupting ratings			105	250
69	All interrupting ratings			160	350
92	All interrupting ratings			210	450
115	All interrupting ratings			260	550
138	All interrupting ratings			310	650
161	All interrupting ratings			365	750
196	All interrupting ratings			425	900
230	All interrupting ratings			485	1,050
287.5	All interrupting ratings			590	1,300
345	All interrupting ratings			690	1,550

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a. When the dielectric strength of a circuit breaker is dependent upon taping of the leads, or the use of special insulation, such taping or special insulation may be used when the factory test is made.

b. For indoor breakers these impulse test values become effective July 1, 1943.

c. Applied to tests across open contacts of magnetic-type air breakers only. These values are below the basic insulation levels, but they represent present-day design practice. It is the intention that these values are to be increased where possible.

d. Where indoor breakers rated at 15, 23, and 34.5 kv are used at lower voltages, or applied on grounded neutral systems where adequate surge or overvoltage protection is provided, the impulse tests may be specified as 95, 110, and 150 kv, respectively. Such applications should be given special consideration.

Table III. Standard Insulation Test Voltages. Outdoor Air Switches and Bus Supports

	Standard Insulation Tests—Withstand Voltage—Kv	
Insulation Class	Low Frequency One Minute (Dry)	Impulse 1.5x40-μsec Full Wave (Pos. or Neg.)
7.5	36	95
15	50	110
23	60	150*
34.5	80	200*
46	105	250*
69	160	350
92	210	450**
115	260	550
138	310	650**
161	365	750
196	425	900
230	485	1050
287	590	1300
345	690	1550

* For certain apparatus including air switches and bus insulators, the impulse levels indicated shall become effective on July 1, 1943; in the interim, and for existing designs of this equipment, values of 145, 190, and 240 kv will be recognized as exceptions for these three classes respectively.

** There is no standard switch and bus insulator available for this impulse level. When required, use the next higher level.

Air switches in the full open position shall be capable of withstanding between live parts voltage tests of 10% in excess of the maximum voltage test which they shall withstand to ground.

Table IV. Indoor Air Switches and Bus Supports

	Standard Insulation Tests—Withstand Voltage—Kv	
Insulation Class*	Low Frequency One Minute (Dry)	Impulse 1.5x40-μsec Full Wave (Pos. and Neg.)
2.5/5	19	45
5/7.5	26	60
7.5/15	36	95
15/23	60	110
23/34.5	80	150

* The first figure (left hand) in Insulation Class applies to devices for fully insulated systems. The second figure (right hand) may apply to devices for grounded neutral systems where adequate surge voltage protection is provided, or to systems not exposed to lightning.

These values are below the basic insulation levels, but they represent present day design practice.

rated 600 volts and above (AIEE report on a proposed Standard) is still in process. However, for outdoor fuses rated 23 kv and above the approved test voltages are the same as given in Table II for outdoor breakers of the same voltage class, with the provision that the 23-, 34.5-, and 46-kv air switches would not have to meet the new impulse test values until July 1, 1943. Complete outdoor fuses rated 23 kv and above should also withstand a 10-second wet test of twice rated voltage plus 1,000 volts.

Due to complexity of switchgear assemblies covered by AIEE Standard 27, it has been impractical to agree on impulse tests for such complete equipment. However, the low-frequency tests given in Table V appear in the AIEE revised Standard 27.

Table V. Standard Insulation Test Voltages

Switchgear Assemblies Rated 2,500 V and Above

When high potential d-c tests are made, the d-c values shall not exceed 1.4 times the corresponding 60 cycle rms test voltage value. Potential transformers having inherently lower insulation strength should be disconnected for these tests

Insulation Class Kv	Switchgear Assemblies With Power Circuit Breakers Having the Following Range of Interrupting Ratings	Standard Insulation Tests 60 Cycle—Kv
2.5	25,000 to 50,000 kva	15
	Above 50,000 kva	19
5.0	25,000 kva and above	19
7.5	25,000 to 150,000 kva	26
	Above 150,000 kva	36
15	Air and oil 25,000 to 250,000 kva, also, oil 500,000 kva with 3 phases in one tank, and to comparable air breakers above 250,000 to 500,000 kva	36
15	Oil with each phase in one tank and to comparable air breakers 500,000 kva and above	50
23	All interrupting ratings	60
34.5	All interrupting ratings	80

Note: Supplementary wet test on entrance bushings for switchgear assemblies for outdoor use: As a supplementary test, entrance bushings on switchgear assemblies for outdoor use should be capable of withstanding for ten seconds a dielectric wet test as a design test only at twice rated voltage plus 1,000 volts. This assumes a precipitation of two-tenths inch (5.08 mm) per minute at an angle of 45 degrees from the perpendicular with water having a resistivity of 6,000–8,000 ohms per inch cube (51,200–20,300 ohms per centimeter cube).

Standard dielectric tests as of the date of issuance of this standard are low frequency only. Impulse voltage tests will be added when agreement is reached concerning the values to be used for switchgear assemblies.

Canadian Sales of "Definitions of Electrical Terms"

Copies of the American and Canadian Standard, *C*42, "Definitions of Electrical Terms" may be obtained by residents of Canada directly from The Canadian Engineering Standards Association, National Research Building, Ottawa, Ont., at $1.15 per copy, a cost lower than it is possible for them to obtain copies directly from AIEE headquarters in New York, N. Y. This is because quantity purchase by the CESA permits some reduction on the usual custom charges on single copies mailed to Canada from the United States. Over 9,000 copies of *C*42 have already been placed in the hands of engineers, scientists, and many other interested individuals throughout the United States and Canada.

PERSONAL • • • •

S. H. Mortensen (A'09, F'20) engineer in charge of a-c design, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed chief electrical engineer of that company's plants at West Allis, Wis., Cincinnati, Ohio, Boston, Mass., and Pittsburgh, Pa. He was born at Eskelund, Denmark, on November 4, 1878, and graduated from the Polytechnicum of Mittweida with the degrees of mechanical and electrical engineer in 1902. He joined the mechanical engineering department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., in 1902. In 1905 he was employed by the Bullock Electric Manufacturing Company, Cincinnati, Ohio. He joined the Allis-Chalmers company in 1908 and was made designing electrical engineer for d-c motors and generators in that year. In 1909 he became designing electrical engineer for a-c turbogenerators. He was placed in charge of the design of synchronous motors and generators in 1911. In 1932 he was made engineer in charge of a-c design. He has been active in the development of self-starting synchronous motors, synchronous condensers, and turbogenerators. He is the author of a textbook on the design of motors and generators.

N. B. Higgins (A'19, M'27) chief engineer, Safe Harbor Water Power Corporation and Pennsylvania Water and Power Company, both of Baltimore, Md., has been elected president of the Safe Harbor company. He has resigned his position with the Pennsylvania company. Born on February 15, 1885, at Morris Run, Pa., he received the degree of bachelor of science in civil engineering in 1909 from Pennsylvania State College. He was engaged in civil engineering work from 1910 to 1913, when he became chief draftsman, Pennsylvania Water and Power Company. In 1918 he was made engineer of design and maintenance, and in 1919, assistant chief engineer. In 1929 he became assistant chief engineer with the Safe Harbor Water company also. Since 1933 he had been chief engineer of both the Pennsylvania and Safe Harbor companies. He played a large part in the design and construction of the Holtwood hydroelectric development of the Pennsylvania Water and Power Company and the Safe Harbor hydroelectric project. He is also a member of The American Society of Mechanical Engineers, the American Society for Testing Materials, and the American Welding Society.

C. A. Molsberry (A'29) engineer, United Illuminating Company, New Haven, Conn., has been appointed general superintendent of production. He received the degree of bachelor of science in electrical engineering from Iowa State College. In 1922 he was employed by the General Electric Company in the testing department. In 1923 he entered the switchgear department, in 1924 the central-station department, and in 1928 he was appointed engineer at the New Haven office. He joined the United company in 1935 as district engineer at New Haven. He was general engineer for the company from 1936 to 1939, when be became assistant manager of engineering. **P. V. Plummer** (A'33) engineering department, has been appointed assistant to Mr. Molsberry in charge of design and construction. He joined the company in 1928 and in 1930 became assistant to the chief operator in charge of construction and maintenance. In 1940 he was appointed design and construction engineer for the generating department.

W. E. Enns (A'37) electrical engineer, Portland (Oreg.) General Electric Company, has received the 1941 AIEE District 9 prize for initial paper for his paper, "Methods and Apparatus for A-C Network Analysis Using Resistance Networks." He was born on November 8, 1901, Trenton, Mo., and received the degree of bachelor of science in electrical engineering from the University of California. From 1925 to 1929 he was employed as senior electrical designer by the Southern California Edison Company, Los Angeles, Calif., and in 1929 he joined Electrical Research Products, Inc., Los Angeles. He became electrical draftsman in the engineering department of the Bureau of Power and Light, Los Angeles, Calif., in 1935, and in 1936 he joined the Portland (Oreg.) General Electric Company as an assistant electrical engineer. In 1941 he was appointed electrical engineer. He is also a member of Eta Kappa Nu.

C. L. Matthews (A'09, F'27) former vice-president and general manager, W. N. Matthews Corporation, St. Louis, Mo., has been elected president of that company. In 1899 he joined the Packard Electric Company, Warren, Ohio, and the following year he was employed in the drafting department of the Packard Motor Car Company, Warren, Ohio. He joined the firm of W. N. Matthews and Brother, St. Louis, Mo., as junior partner in 1901 and has been with that company or its successors since then. He has been in charge of engineering for the Matthews company since 1901 and in that capacity has worked on the development, design, and production of electric devices. In 1908 he began the development of fuse and disconnecting switches. He is the holder of several patents.

H. B. Reynolds (M'41) mechanical engineer, New York City Transit System, has been appointed superintendent of motive power of that company's Interborough Rapid Transit division. He was employed by the Interborough Rapid Transit Company, New York, N. Y. from 1914 to 1917. After working as mechanical assistant to the superintendent of motive power, United Railways and Electric Company, Baltimore, Md., and as fuel engineer with the United States Government, Bureau of Mines, he returned to the Interborough Rapid Transit Company in 1919 as mechanical research engineer. When that company was taken over by the New York City Transit System, he remained as mechanical engineer with the IRT division.

Bern Dibner (A'23, F'42) vice-president and general manager, Burndy Engineering Company, New York, N. Y., has been commissioned as a captain in the United States Air Corps. **Marvin Lee** (A'35, M'41) chief engineer of the Burndy company has been elected acting general manager. He was graduated from Brooklyn Polytechnic Institute in 1922 with the degree of electrical engineer and has been with the Burndy company since 1925.

C. L. Derrick (A'40) engineer, Public Service Electric and Gas Company, Irvington, N. J., has been appointed assistant engineer of the Hartford (Conn.) Electric Light Company. He was graduated from Lehigh University with the degree of electrical engineer in 1923 and in that year joined the Public Service Electric and Gas Company as a cadet engineer. From 1926 to 1936 he was assistant engineer and in 1936 he was made engineer.

J. W. McLaughlin (A'39) former associate engineer, National Power Policy Committee, Washington, D. C., who is now a lieutenant commander in the United States Naval Reserve has been appointed chief of the power and electrical unit and also has been named Navy clearance officer with the power branch of the War Production Board, for the priorities division of the Army and Navy munitions board.

R. E. Greene (A'26) senior engineer, engineering division, Detroit (Mich.) Edison Company, has been appointed construction engineer. In 1919 he was employed in the testing department of the General Electric Company, Schenectady, N. Y., and in 1926 he was transferred to the central-station engineering department. In 1937 he entered the construction bureau of the Detroit Edison Company.

J. R. Murphy (A'20) manager, General Electric Company, Spokane, Wash., has been assigned to represent that company in Washington, D. C. He will be succeeded by **J. F. Gogins** (A'40) salesman, who entered the General Electric Company's test course, Schenectady, N. Y., in 1930. He joined the Spokane office in 1935.

J. E. Woodward (A'42) second lieutenant, United States Army, was awarded the AIEE 1941 Southern District (4) prize for Branch paper for his paper, "The Vectorscope." The award was presented at the annual Southern District convention of Student Branches, held at the University of Alabama, April 3–5, 1941. He was born in Greenville, S. C., on October 14, 1919, and was graduated with the degree of electrical engineering from Clemson College, June 1941. After a short time as student engineer at the Philadelphia, Pa., works of the General Electric Company, he resigned to enter the army. He also is a member of Tau Beta Pi and Phi Kappa Phi.

William H. Harrison (A'20, F'31) on leave as vice-president and chief engineer of the American Telephone and Telegraph Company, New York, N. Y., and recently appointed colonel in the United States Army has become brigadier general in charge of production activities of the Services of Supply. He is a past president (1937–38) and vice-president (1935–37) of the AIEE.

C. O. Bickelhaupt (M'22, F'28) vice-president, American Telephone and Telegraph Company, New York, N. Y., is now a colonel in the United States Army, serving as assistant to the chief signal officer of the Signal Corps, Washington, D. C. (For a complete biographical sketch, see *EE, Feb. '42, p. 94.*)

F. C. Todd (A'27) assistant professor, mineral industries experiment station, Pennsylvania State College, State College, Pa., has received the Charles B. Dudley Medal of the American Society for Testing Materials for the paper, "Studies on Measurement of Water Vapor in Gases," written in collaboration with A. W. Gauger.

Gano Dunn (A'91, F'12) president, J. G. White Engineering Corporation, New York, N. Y., has received an honorary degree of doctor of engineering from Lehigh University. Doctor Dunn is an AIEE past president, and has received the Edison and Hoover Medals, in addition to other honors and honorary degrees.

W. V. Kahler (M'39) chief engineer, Illinois Bell Telephone Company, Chicago, who has been on leave of absence serving as head of the construction branch of the production division of the War Production Board, has been appointed head of a new bureau consolidating WPB construction functions.

G. W. Hart (A'31) sales consultant, Ebasco Services, Inc., New York, N. Y., has joined the Government contract service staff of the radio division of the Western Electric Company, New York, N. Y. He had been with Ebasco Services Inc., since 1936.

J. A. Morris (A'31) meter engineer, Sao Paulo (Brazil) Tramway, Light, and Power Company, Ltd., is now associated with the American Gas and Electric Service Corporation, New York, N. Y. He had been employed by the Sao Paulo Tramway, Light, and Power Company since 1928.

E. W. Kimbark (A'27, M'35) associate professor and acting chairman of the electrical engineering department, Northwestern University, Evanston, Ill., is on leave of absence at Massachusetts Institute of Technology, Cambridge, teaching special courses for Army and Navy officers.

L. M. Goldsmith (M'26) chief engineer, engineering and construction department, Atlantic Refining Co., Philadelphia, Pa., received recently an honorary degree of doctor of science from Drexel Institute of Technology.

F. W. Bliss (A'30) New England district manager, sales development department, General Electric Company, Boston, Mass., is serving as co-ordinator for the city of Boston on the Massachusetts Industrial Committee for National Defense.

R. B. Shepard (A'25, F'36) electrical engineer, Underwriters Laboratories, New York, N. Y., has been appointed deputy chief of the simplification branch of the bureau of industrial conservation of the War Production Board, Washington, D. C.

C. C. Hutchins (A'23, M'29) electrical engineer, Elliott Company, Pittsburgh, Pa., has been appointed executive engineer in charge of product engineering at that company's Ridgway works. He has been with the Elliott Company since 1927.

Joseph Clark (A'26, M'35) assistant engineer, electrical engineering department, Consolidated Edison Company of New York (N. Y.), is on leave of absence, now serving with Jackson and Moreland, Boston, Mass.

E. L. Phillips (M'26) chairman of the board, Long Island Lighting Company, New York, N. Y., has been awarded the honorary degree of doctor of laws by Ohio Wesleyan University by Florida Southern College.

J. V. Wall (A'27) electrical engineer, Elwood Ordnance Plant, Sanderson and Porter, consulting engineers, is now associated with Vern E. Alden, consulting engineer, with headquarters at Chicago, Ill.

T. J. Higgins (A'40) assistant professor, department of electrical engineering, Tulane University, New Orleans, La., has been appointed associate professor in the department of electrical engineering, Illinois Institute of Technology, Chicago.

W. J. Ellenberger (A'31, M'38) power engineer, Potomac Electric Power Company, Washington, D. C., is now a first lieutenant in the Signal Corps of the United States Army.

F. H. McIntosh (M'37) technical director, Fort Industry Company, Toledo, Ohio, has become chief of the radio section of the communications branch, division of industry operations, War Production Board.

C. F. Kettering (A'04, F'14) vice-president in charge of research, General Motors Corporation, Dayton, Ohio, has been named consultant to the radio and radar branch of the War Production Board.

L. E. Messinger (A'30) president, Canadian Line Materials, Ltd., Toronto, Ont., has been made assistant to the chairman of the War Time Trade and Price Board of Canada.

W. R. Lyon (A'20, M'26) factory representative United States Army Air Corps, with Wright Aeronautical Corporation, Lockland, Ohio, is now stationed at South Bend, Ind., as resident representative.

C. S. Redding (A'12, M'41) president, Leeds and Northrup Company, Philadelphia, Pa:, has been elected president of the Franklin Institute. He was formerly a manager of that organization.

F. A. Hansen (M'31) managing director, The Western Institute of Light and Vision, Los Angeles, Calif., recently received the honorary degree of master of science from the University of Southern California.

Vannevar Bush (A'15, F'24) president, Carnegie Institute of Washington (D. C.) has been awarded the honorary degree of doctor of laws by Yale University.

S. E. Gates (A'36) manager, Los Angeles (Calif.) office, General Electric Company, has been elected president of the Pacific Coast Electrical Association.

C. C. Sowards (A'40) sales engineer, Copperweld Steel Company, New York, N. Y., is now in the United States Army stationed at a Midwest ordnance plant.

OBITUARY • • • •

William Herrman Brenner (A'93, M'94) retired engineer, Atlanta, Ga., died on June 20, 1942. He was born at Augusta, Ga., on December 20, 1860. From 1883 to 1886 he was employed in the engineering department of the New York (N. Y.) Edison Company, and from 1886 to 1887 he was superintendent and electrician with the Edison Electric Illuminating Company, Cincinnati, Ohio. He was engaged in electric-light and railway construction in Tokyo, Japan, from 1887 to 1891, when he became district engineer for the Edison General Electric Company, Toronto, Ontario. From 1892 to 1894 he was an electrical engineer with the Montreal (P. Q.) Street Railway. In 1894 he joined the Electrical and Mechanical Engineering Company, New York, N. Y., and the following year he joined the Electric Storage Battery Company, Philadelphia, Pa., with headquarters in New York. In 1896 he became construction engineer for the New York and Staten Island Electrical Company, Livingston, N. Y. From 1897 to 1900 he was engineering manager for Frazer and Company, Yokohama, Japan, and from 1900 to 1909 he was managing director and chief engineer at the Zemma Works, Yokohama, Japan. In 1909 he became manager of the British Columbia Manufacturing Company, New Westminster, and in 1911 he joined the Electromotor Equipment Company, London, England, as managing director. He served as director, Gerente de la Fabrica Cia, Anglo-Espanola de Cemento Portland, Matillas, Spain, from 1913 to 1929 when he retired. He was also a member of The American Society of Mechanical Engineers.

Frederick A. Allner (A'12, M'14) president, Safe Harbor Water Power Corporation, Baltimore, Md., died on July 18, 1942. He was born at Skytal, Austria, on July 19, 1882, and was graduated from the Technical College of Prague with the degree of mechanical engineer in 1904. From 1905 to 1907 he was employed as designing engineer for a-c generators, motors, and transformers with the Elektrizitaets Aktein Gesellschaft vormals Kolben and Company, Prague, and in 1907 he joined the Gesellschaft fuer Elektrische Industrie, Karlsruhe, Germany, as a designing and testing engineer for turbogenerators. He was employed as an engineer in the standard practice and shop management department, American Locomotive Company, Montreal (P. Q.) Locomotive Works in 1908 and the following year he became electrical and mechanical engineer for the Shawinigan Water and Power Company, Montreal, P. Q. In 1909 he joined the McCall Ferry Power Company, Holtwood, Pa. (later the Pennsylvania Water and Power Company) as assistant chief engineer, in 1911 became general superintendent, and later vice-president. He became general superintendent of the Safe Harbor Water Power Corporation in 1929 and was elected president in 1940. He was also a member of The American Society of Mechanical Engineers and the American Society of Civil Engineers.

John Coffee Hays (A'04, M'13) executive vice-president, Stone and Webster Engineering Corporation, New York, N. Y., died on July 21, 1942. He was born on January 5, 1883, in Tulane County, Calif. From 1899 to 1903 he was employed by the Mount Whitney Power Company, Visalia, Calif., except for a brief period with Henshaw Bulkly and Company, San Francisco, Calif. During 1903–04 he was employed by the Stanley Electric Manufacturing Company, Pittsfield, Mass. In 1904 he joined L. B. Stillwell, consulting engineer, New York, N. Y. In 1907 he became president, general manager, and consulting engineer of a group of utilities and hydroelectric projects in California, including the Mount Whitney Power Company, Yosemite Power Company, Tuolumino Power and Light Company, La Grange Water and Power Company, and Mount Shasta Power Company. In 1915 he went to San Francisco, Calif. as a consulting engineer and in 1919 he joined the Stone and Webster Engineering Corporation as a hydraulic engineer. He became vice-president of that company in 1929 and executive vice-president in 1938. He was also a member of the American Society of Civil Engineers and The American Society of Mechanical Engineers.

Henry Gerber Reist (A'90, M'94, F'13) retired head of the motor and generating engineering department, General Electric Company, Schenectady, N. Y., died July 5, 1942. He was born at Mount Joy, Pa., on May 27, 1862, and was graduated from Lehigh University with the degree of mechanical engineer in 1886. After working in the testing and drafting departments of the Foundry and Machine Company, Harrisburg, Pa., he joined the Thomson-Houston Electric Company, Lynn, Mass. (later a part of the General Electric Company), in 1889. In 1894 he took charge of the design and construction of alternating current machinery and in 1931 he retired. He held a number of patents for inventions, among which was a fabricated structure to replace castings in electric apparatus. He was a member and past vice-president of The American Society of Mechanical Engineers, and a member of the American Association for the Advancement of Science. He was also a member of Tau Beta Pi and Sigma Xi.

Hewlitt Scudder (A'99) retired assistant patent attorney, General Electric Company, Schenectady, N. Y., died July 31, 1942. He was born in New York, N. Y., on August 9, 1875 and received the degrees of bachelor of arts from Yale University in 1896 and master of arts and electrical engineer from Columbia University in 1899. He joined the General Electric Company at Schenectady, N. Y., in 1902 as a test engineer. In 1905 he was transferred to the railway engineering department and in 1907 he joined the patent department. In 1911 he was placed in charge of foreign patents and when the International General Electric Company was formed, he was placed in charge of its foreign work. He was also a member of The American Society of Mechanical Engineers.

Charles L. Cornell (A'90, M'95) retired electrical engineer and former executive vice-president of the Niles-Bement-Pond Company, New York, N. Y., and its subsidiary, the Pratt and Whitney Machine Tool Company, died July 18, 1942. He was born at Hamilton, Ohio, on September 7, 1861, and was graduated from Cornell University in 1889. From 1889 to 1890 he was construction engineer at Kearney, Nebr. He was employed by the Omaha (Nebr.) Street Railway during 1890, and later he was engaged in business as a construction engineer and contractor in the Middle West. In 1899 he had a part in organizing the Niles-Bement-Pond Company and was its treasurer until 1907, when he was made executive vice-president. He retired in 1925.

Dick Pyper (A'29) foreman, hydroelectric power station, Compania Minera Choco Pacifico, Andagoya, Colombia, South America, died on March 6, 1942. He was born on April 11, 1900, at Oostwoud, Holland. In 1920 he was employed by the Toronto Power Company, Niagara Falls, Ontario and in 1926 he went to Chile to serve as switchboard operator with the Braden Copper Company. In 1927 he became chief operator and load dispatcher and the following year he became also relief generating-station foreman. In 1930 he was employed by the Southern California Edison Company, Big Creek, Calif., and from 1934 to 1938 he was an operator at the hydroelectric powerhouse, Turlock Irrigation District, La Grange, Calif.

Richard Thomas Durran (A'05) electrical engineer, London, England, died on June 5, 1942. Born at London on April 16, 1876, he was a graduate of Finsbury Technical College. After being employed by J. G. Statter and Company for a year, he was assistant to the editor of a publication entitled, "Electrician." Later he was employed by W. H. Allen Son and Company, Ltd., Bedford, England, as general mechanical and electrical engineer. He joined the Allgemeine Elektricitats Gesellschaft, Berlin, Germany, as an engineer in the foreign department and later was appointed manager.

MEMBERSHIP • •

Applications for Election

Applications have been received at headquarters rom the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before September 30, 1942, or November 30, 1942, if the applicant resides outside of the United States or Canada.

United States and Canada

1. NORTH EASTERN

Allain, A. R., Jr., Vulcan Electric Corporation, Danvers, Mass.
Fagen, M. D. (Member), Massachusetts Institute of Technology, Cambridge, Mass.
Goodwin, F. R., Narragansett Electric Company, Providence, R. I.
Guillemette, J. D. (Member), Jenks and Ballou, Providence, R. I.
Jerencsik, A. P., General Electric Company, Schenectady, N. Y.
Klauber, P. M., General Electric Company, Schenectady, N. Y.
Nelson, E. J., Rochester Gas and Electric Corporation, Rochester, N. Y.
Reinhardt, H. (Member), Hygrade Sylvania Corporation, Danvers, Mass.
Sills, R. H., Eastman Kodak Company, Rochester, N. Y.
Wight, J. C., General Electric Company, Bridgeport, Conn.

2. MIDDLE EASTERN

Anderson, R. P. (Member), Cutler Hammer, Inc, Cleveland, Ohio.
Byers, G. M., Navy Department, Philadelphia, Pa.
Daugherty, W. E., Bethlehem Steel Company, Baltimore, Md.
Foss, F. A. (Member), United States Corps of Engineers, Lockbourne Army Airbase, Ohio.
Frye, H. B., United States Engineer Office, Wright Field, Dayton, Ohio.
Grant, R. M., Allis-Chalmers Manufacturing Company, Pittsburgh, Pa.
Gregory, C. A., Jr., Washington and Jefferson College, Washington, Pa.
Gross, G. C. (Member), Federal Communications Commission, Washington, D. C.
Lewis, J. H., Philadelphia Electric Company, Philadelphia, Pa.
Lynch, N. C., Wm. E. Kingswell, Inc., Washington, D. C.
Newton, G. C., Jr., York Safe and Lock Company, York, Pa.
Potter, E. G., The Lima Armature Works, Lima, Ohio.
Saunders, C. C. (Member), E. I. Du Pont de Nemours, Wilmington, Del.
Strickler, W. A., Jr., The North Electric Manufacturing Company, Galion, Ohio.

3. NEW YORK CITY

Armstrong, W. P., George S. Armstrong and Company, Inc., New York, N. Y.
Grossfeld, C. (Member), Bronx Vocational High School, Bronx, N. Y.
Key, E. G., United States Army, Signal Corps, Fort Monmouth, N. J.
Kohl, H. S., Nichols Engineering and Research Corporation, New York, N. Y.
Lange, W. F., Gibbs and Cox, Inc., New York, N. Y.
Miner, R. Y. (Associate re-election), Arma Corporation, Brooklyn, N. Y.
Stobbe, J. A., 63 Wall Street, New York, N. Y.
Straube, W. T. (Member), 653—53d Street, Brooklyn, N. Y.
Valesio, M. J. (Associate re-election), Office of the Borough President of Manhattan, New York, N. Y.
Witkus, V. W., Western Electric Company, Kearny, N. J.

4. SOUTHERN

Bason, G. F. (Associate re-election), Durham, N. C.
Brumleve, C. C., Thermex Division–Girdler Corporation, Louisville, Ky.
Fortney, J. G., Reynolds Alloys Company, Lister, Ala.
Goldan, A. S. (Associate re-election), Pan American Airways, Miami, Fla.
King, H. W. (Member), Sangamo Electric Company, Louisville, Ky.
Lamb, R. V., 207 N. Martin Street, Elizabeth City, N. C.
Parker, G. R., Electric Power Board, Chattanooga, Tenn.
Parker, R. M. (Member), United States Engineer Office, Fort Custis, Va.
Rackle, E. E., Waterman Steamship Corporation, Mobile, Ala.
Webb, H. E., Jr., United States Army Air Forces, Tuskegee Army Flying School, Tuskegee, Ala.

5. GREAT LAKES

Amos, L., Delco Remy, Anderson, Ind.
Barnes, E. W., Sargent and Lundy, Chicago, Ill.
Borland, C. A., Western Electric Company, Inc., Chicago, Ill.
Buchanan, G. E. (Associate re-election), Delta-Star Electric Company, Chicago, Ill.
Deppe, R. M. (Member), Commonwealth Edison Company, Chicago, Ill.
Gwyn, C. B., Jr. (Member), Fansteel Metallurgical Corporation, North Chicago, Ill.
Kirwen, M. S. (Associate re-election), The Commonwealth and Southern Corporation, Jackson, Mich.
Kronmiller, C. W., General Electric Company, Fort Wayne, Ind.
Reynolds, F. B. (Member), Graybar Electric Company, Madison, Wis.
Sinish, R. D., General Electric Company, Fort Wayne, Ind.
Smith, R. E., Wincharger Corporation, Sioux City, Iowa.
Smith, W. H., Jr., Tri-State College, Angola, Ind.
Swinney, J. W., Delco Remy Division of General Motors, Anderson, Ind.
Watson, R. W., Westinghouse Electric and Manufacturing Company, Chicago, Ill.
Wirt, J. R., Delco Remy Division, General Motors Corporation, Anderson, Ind.

6. NORTH CENTRAL

Stark, R. L., United States Bureau of Reclamation, Kremmling, Colo.
World, R. W., Bureau of Reclamation, Denver, Colo.

7. SOUTH WEST

Bodin, J. A., Schlumberger Well Surveying Corporation, Houston, Tex.
Brown, H. H., St. Louis Ordnance Plant, St. Louis, Mo.
Eisler, H. C., Kansas Electric Power Company, Emporia, Kans.
Gould, H. M. (Member re-election), Smith, Hinchman, and Grylls, Inc., Lake City, Mo.
Kersh, R. S., Westinghouse Electric and Manufacturing Company, Houston, Tex.
Moore, J. H., Rural Electrification Administration, St. Louis, Mo.

8. PACIFIC

Boyd, W. E., Pacific Electric Motor Company, Oakland, Calif.
Caswell, R. A. (Member), United States Army Signal Corps, Fort Mason, San Francisco, Calif.
Dahlstrum, A., Vultee Aircraft, Inc., Vultee Field, Calif.
Goodner, F. S., Mare Island, Calif.
L'Hommedieu, W. R., Westinghouse Electric and Manufacturing Company, Los Angeles, Calif.
Marrs, T., Bureau of Reclamation, Yuma, Ariz.
Moler, M. A., United States Maritime Commission, Oakland, Calif.
Peterson, N. J., General Electric Company, San Francisco, Calif.
Woodard, M. L., Maywood Limited, San Francisco, Calif.

9. NORTH WEST

James, S. D., Lyle, Wash.
Lean, B. W., City Light Department, Cheney, Wash.

10. CANADA

Alexander, F., Burrard Dry Dock Company, Ltd., North Vancouver, B. C.
Donald, H. G., Lloyd's Register of Shipping, Vancouver, B. C.

Total, United States and Canada, 80

Elsewhere

Amster, M. N., The Panama Canal, Diablo Heights, Canal Zone.
Boyce, H. (Member), Royal Navy, Cape Town, South Africa.
Colon, J. (Member), Hidroelectrica del Estado, Quetzaltenango, Guatemala, Central America.
Cox, H. (Member), Derbyshire and Nottinghamshire Electric Power Company, Derbyshire, England.
Davis, P., P.W.D. Electricity Branch, Lyallpur Division, Punjab, India.
Gonzalez, E. (Member), Bolivian Power Company Ltd., Oruro, Bolivia, S. A.
Harskin, M., British Power Transformer Company, Ltd., Enfield, Middlesex, England.
Jenkins, D. F. L. W., Messrs. Johnson and Phillips Ltd., London, S.E. 7, England.
Jennings, F. M. (Member), United States Corps of Engineers, Ancon, Canal Zone.
Khan, M. A. (Member), Manavadar, Kathiawar, India.
Satyanarayana, A. V., Indian Army Ordnance Corps, Base Post Depot, Karachi, Jebbulpure, India.

Total, elsewhere, 11

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute record. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Abell, Elwyn D., 1168 Glenwood Blvd., Schenectady, N. Y.
Allen, Richard L., 2922—18th St., N. W., Washington, D. C.
Bean, William S., Jr., 1108 Baker Ave., Schenectady, N. Y.
Christiansen, August Glenn, 532—72nd St., Brooklyn, N. Y.
Coryell, Walter R., Central Y.M.C.A., 9th and La Salle Sts., Minneapolis, Minn.
Day, William M., 2821 St. Paul St., Baltimore, Md.
Degentesh, H. E., 310 Riverside Drive, New York, N. Y.
Eager, George S., Jr., 19 Wabeno St., Boston, Mass.
Eddie, W., Jr., 1725 Pierrie Ave., Windsor, Ont., Can.
Evans, T. C., Jr., 160—16th Ave., N. W., Washington, D. C.
Greenlees, Charles R., Jr., 1903 Kalorama Road, Washington, D. C.
Hafely, Charles Harold, 715 W. Maumee, Angola, Ind.
Hilt, William Myron, 30 W. Chicago Ave., Chicago, Ill.
Innis, Harry H., 5325 Forbes St., Pittsburgh, Pa.
Johnson, Joseph E., 1631 S. 49th Court, Cicero, Ill.
Kettering, Clifford C., 403 Westminster, Los Angeles, Calif.
Klein, William, 219 Echo Place, New York, N. Y.
Levy, Harold C., 1523 Stone, Great Bend, Kans.
McConnell, Malcolm E., 5424—5th Ave., Pittsburgh, Pa.
Montgomery, W. E., 401 S. Electric, Alhambra, Calif.
Moore, W. H., 600 Braxton Place, Alexandria, Va.
Moull, W. C., 555 Chamberlain St., Peterboro, Ont., Can.
Osteen, William C., Southern California Edison Co., Ltd., South Pasadena, Calif.
Schrawder, Robert Rat, 606 Pine St., Lancaster, Pa.
Smith, Henry A., 4232 Baring Ave., East Chicago, Ind.
Taylor, Richard V., 1825 G St., N. W. Washington, D. C.
Warriner, Robert R., 4251 W. Irving Park Road, Chicago, Ill.
Wirpio, Carl I., 1000 Central Ave., Louisville, Ky.

28 Addresses Wanted

Officers and Committees for 1942–43

Officers

President

HAROLD S. OSBORNE	New York, N. Y.

(*Term expires July 31, 1943*)

Junior Past Presidents

R. W. SORENSEN	Pasadena, Calif.

(*Term expires July 31, 1943*)

DAVID C. PRINCE	Schenectady, N. Y.

(*Term expires July 31, 1944*)

Vice-Presidents

District		
2	(To be announced)	
4	J. ELMER HOUSLEY	Alcoa, Tenn.
6	ARTHUR L. JONES	Denver, Colo.
8	WALTER C. SMITH	San Francisco, Calif.
10	C. A. PRICE	Hamilton, Ont.

(*Terms expire July 31, 1943*)

1	K. B. McEACHRON	Pittsfield, Mass.
3	CHARLES R. JONES	New York, N. Y.
5	A. G. DEWARS	Minneapolis, Minn.
7	E. T. MAHOOD	Kansas City, Mo.
9	E. W. SCHILLING	Bozeman, Mont.

(*Terms expire July 31, 1944*)

Directors

MARK ELDREDGE	Washington, D. C.
C. M. LAFFOON	East Pittsburgh, Pa.
F. J. MEYER	Oklahoma City, Okla.

(*Terms expire July 31, 1943*)

T. F. BARTON	New York, N. Y.
M. S. COOVER	Ames, Iowa
R. G. WARNER	New Haven, Conn.

(*Terms expire July 31, 1944*)

L. R. GAMBLE	Spokane, Wash.
T. G. LeCLAIR	Chicago, Ill.
FRED R. MAXWELL, JR.	Pensacola, Fla.

(*Terms expire July 31, 1945*)

K. L. HANSEN	Milwaukee, Wis.
W. B. MORTON	Glenside, Pa.
W. R. SMITH	Newark, N. J.

(*Terms expire July 31, 1946*)

National Treasurer

W. I. SLICHTER	Schenectady, N. Y.

(*Term expires July 31, 1943*)

National Secretary

H. H. HENLINE	New York, N. Y.

(*Term expires July 31, 1943*)

Local Honorary Secretaries

AUSTRALIA—V. J. F. Brain, Department of Public Works, Bridge Street, Sydney, N.S.W.

BRAZIL—Richard H. Bowles, Sao Paulo Tramway Light and Power Company, Sao Paulo.

ENGLAND—A. P. M. Fleming, Metropolitan-Vickers Electric Company, Trafford Park, Manchester.

FRANCE—A. S. Garfield, 173 Boulevard Haussmann, Paris, 8E.

INDIA, NORTHERN—V. F. Critchley, 3 Abbot Road, Lahore, Punjab.

INDIA, SOUTHERN—N. N. Iengar, The Tata Power Co. Ltd., Bombay House, Bruce Street, Fort Bombay.

NEW ZEALAND—P. H. Powell, Canterbury College, Christchurch.

SWEDEN—A. F. Enstrom, Ingeniorsvetenskrapsakademien, Stockholm, 5.

TRANSVAAL, SOUTH AFRICA—W. Elsdon-Dew, P. O. Box 4563, Johannesburg.

General Committees

Executive

Harold S. Osborne, *chairman*, 195 Broadway, New York, N. Y.

T. F. Barton
C. R. Jones
David C. Prince
W. I. Slichter
R. W. Sorensen
R. G. Warner

Board of Examiners

A. E. Knowlton, *chairman*, *Electrical World*, 330 W. 42d Street, New York, N. Y.

H. E. Farrer, *secretary*, AIEE, 33 W. 39th Street, New York, N. Y.

P. H. Adams
M. C. Beebe
L. W. Chubb
F. E. D'Humy
E. D. Doyle
J. F. Fairman
A. L. Harding
L. F. Hickernell
Alexander Maxwell
K. B. McEachron
L. W. W. Morrow
R. C. Roe
H. S. Warren
R. J. Wiseman
Sidney Withington

Code of Principles of Professional Conduct

Dugald C. Jackson, *chairman*, 5 Mercer Circle, Cambridge, Mass.

Harry Barker
C. R. Beardsley
D. D. Ewing
W. M. Piatt
Walter C. Smith
G. A. Waters

Constitution and Bylaws

I. Melville Stein, *chairman*, Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.

C. A. Powel, *vice-chairman*, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

Mark Eldredge W. I. Slichter R. L. Jones

Edison Medal

Appointed by the president for term of five years

J. W. Barker N. E. Funk, *chairman* W. H. Harrison
(*Terms expire July 31, 1943*)

W. B. Kouwenhoven F. V. Magalhaes
L. W. W. Morrow
(*Terms expire July 31, 1944*)

K. T. Compton W. D. Coolidge J. M. Thomson
(*Terms expire July 31, 1945*)

J. T. Barron R. E. Doherty J. V. B. Duer
(*Terms expire July 31, 1946*)

F. D. Newbury David C. Prince W. E. Wickenden
(*Terms expire July 31, 1947*)

Elected by board of directors from its own membership for term of two years

M. S. Coover Mark Eldredge R. W Sorensen
(*Terms expire July 31, 1943*)

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6 North Central	Arthur L. Jones, General Electric Co., P. O. Box 2331, Denver, Colo.	Murray G. Graff, General Electric Co., 650 17th St., Denver, Colo.	E. E. Clark, Colorado State College, Fort Collins, Colo.
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10 Canada	C. A. Price, Canadian Westinghouse Co., Ltd., Sanford Ave. N., Hamilton, Ont.	John M. Somerville, Canadian Porcelain Co., Ltd., Box 428, Hamilton, Ont.	

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Idaho, Univ. of, Moscow	9	R. H. Hull
Illinois Inst. of Technology, Chicago	5	E. H. Freeman
Illinois, Univ. of, Urbana	5	E. A. Reid
Iowa State Col., Ames	5	B. S. Willis
Iowa, Univ. of, Iowa City	5	H. R. Reed
Johns Hopkins Univ., Baltimore, Md	2	F. Hamburger
Kansas State Col., Manhattan	7	J. E. Ward, Jr.
Kansas, Univ. of, Lawrence	7	G. A. Richardson
Kentucky, Univ. of, Lexington	4	E. A. Bureau
Lafayette Col., Easton, Pa	2	F. W. Smith
Lehigh Univ., Bethlehem, Pa	2	J. L. Beaver
Louisiana State Univ., Baton Rouge	4	A. K. Ramsey
Louisville, Univ. of, Louisville, Ky	4	S. T. Fife
Maine, Univ. of, Orono	1	N. E. Wilson
Manhattan Col., New York, N. Y	3	H. J. Lockwood
Marquette Univ., Milwaukee, Wis	5	E. W. Kane
Maryland, Univ. of, College Park	2	L. J. Hodgins
Mass. Inst. of Technology, Cambridge	1	H. B. Dwight
Michigan Col. of Mining & Tech., Houghton	5	G. W. Swenson
Michigan State Col., East Lansing	5	M. M. Cory
Michigan, Univ. of, Ann Arbor	5	J. S. Gault
Milwaukee School of Engg., Milwaukee, Wis	5	E. L. Wiedner
Minnesota, Univ. of, Minneapolis	5	J. H. Kuhlmann
Mississippi State Col., State College	4	H. C. Simrall
Missouri School of Mines & Met., Rolla	7	J. Stuart Johnson
Missouri, Univ. of, Columbia	7	D. Waidelich
Montana State Col., Bozeman	9	G. Fiedler
Nebraska, Univ. of, Lincoln	6	L. A. Bingham
Nevada, Univ. of, Reno	8	S. G. Palmer
Newark Col. of Engineering, Newark, N. J	3	F. A. Russell
New Hampshire, Univ. of, Durham	1	W. B. Nulsen
New Mexico State Col., State College	7	M. A. Thomas
New Mexico, Univ. of, Albuquerque	7	H. L. Jones
New York, Col. of the City of, New York	3	Harry Baum
New York Univ., New York	3	P. C. Cromwell
North Carolina State Col., Raleigh	4	L. M. Keever
North Dakota State Col., Fargo	6	H. S. Rush
North Dakota, Univ. of, Grand Forks	6	C. W. Rook
Northeastern Univ., Boston, Mass	1	R. G. Porter
Northwestern Univ., Evanston, Ill	5	R. W. Jones
Norwich Univ., Northfield, Vt	1	D. E. Howes
Notre Dame, Univ. of, Notre Dame, Ind	5	J. A. Northcott
Ohio Northern Univ., Ada	2	D. S. Pearson
Ohio State Univ., Columbus	2	S. O. Evans
Ohio Univ., Athens	2	W. M. Young
Oklahoma A. & M. College, Stillwater	7	A. Naeter
Oklahoma, Univ. of, Norman	7	C. L. Farrar
Oregon State Col., Corvallis	9	F. O. McMillan
Pennsylvania State Col., State College	2	P. X. Rice
Pennsylvania, Univ. of, Philadelphia	2	S. R. Warren, Jr.
Pittsburgh, Univ. of, Pittsburgh, Pa	2	R. C. Gorham
Puerto Rico, Univ. of, Mayaguez, P. R	3	G. F. Anton
Pratt Institute, Brooklyn, N. Y	3	D. H. Wright
Princeton Univ., Princeton, N. J	2	W. C. Johnson
Purdue Univ., Lafayette, Ind	5	J. H. Karr
Rensselaer Polytechnic Inst., Troy, N. Y	1	E. D. Broadwell
Rhode Island State Col., Kingston	1	
Rice Inst., Houston, Tex	7	C. R. Wischmeyer
Rose Polytechnic Inst., Terre Haute, Ind	5	C. C. Knipmeyer
Rutgers Univ., New Brunswick, N. J	3	J. L. Potter
Santa Clara, Univ. of, Santa Clara, Calif	8	W. J. Warren
South Carolina, Univ. of, Columbia	4	W. M. Bauer
South Dakota State College, Brookings	6	W. H. Gamble
South Dakota State School of Mines, Rapid City	6	E. E. Clark
Southern California, Univ. of, Los Angeles, Calif	8	J. K. Nunan
Southern Methodist Univ., Dallas, Tex	7	H. F. Huffman
Stanford Univ., Stanford University, Calif	8	H. H. Skilling
Stevens Inst. of Technology, Hoboken, N. J	3	W. L. Sullivan
Swarthmore Col., Swarthmore, Pa	2	J. D. McCrumm
Syracuse Univ., Syracuse, N. Y	1	C. W. Henderson
Tennessee, Univ. of, Knoxville	4	W. O. Leffell
Texas A. & M. Col., College Station	7	N. F. Rode
Texas Technological Col., Lubbock	7	C. V. Bullen
Texas, Univ. of, Austin	7	R. A. Galbraith
Tufts College, Tufts College, Mass	1	A. H. Howell
Tulane Univ., New Orleans, La	4	
Union Col., Schenectady, N. Y	1	H. W. Bibber
Utah, Univ. of, Salt Lake City	9	L. Dale Harris
Vermont, Univ. of, Burlington	1	R. O. Buchanan
Villanova Col., Villanova, Pa	2	H. S. Bueche
Virginia Military Inst., Lexington	4	J. S. Jamison
Virginia Polytechnic Inst., Blacksburg	4	Claudius Lee
Virginia Univ. of, University	4	J. S. Miller
Washington, State College of, Pullman	9	H. F. Lickey
Washington, Univ. of, Seattle	9	R. E. Lindblom
Washington Univ., St. Louis, Mo	7	D. A. Fischer
West Virginia Univ., Morgantown	2	A. H. Forman
Wisconsin, Univ. of, Madison	5	E. D. Ayres
Worcester Polytechnic Inst., Worcester, Mass	1	V. Siegfried
Wyoming, Univ. of, Laramie	6	G. H. Sechrist
Yale Univ., New Haven, Conn	1	A. G. Conrad

Total Branches........................124

Local Sections of the Institute

Name	District	When Organized	Membership Aug. 1, 1942	Chairman	Secretary	Secretary's Address
Akron	2	Aug. 12, '20	94	K. F. Sibila	A. G. Seifried	B. F. Goodrich Co., 500 S. Main St., Akron, Ohio
Alabama	4	May 22, '29	44	G. W. McCracken	M. V. Zimmerman	Commonwealth and Southern Corp., Birmingham, Ala.
Arizona	8	Mar. 22, '41	37	G. F. Maughmer	E. A. Gissel	1531 West Encanto Blvd., Phoenix, Ariz.
Boston	1	Feb. 13, '03	516	R. G. Porter	W. I. Middleton	Simplex Wire & Cable Co., Cambridge, Mass.
Central Indiana	5	Jan. 12, '12	133	C. K. Gieringer	J. R. Pies	501 North LaSalle St. Indianapolis, Ind.
Chicago	5	1893	836	J. C. Woods	E. C. Minteer	Minteer & Josler, 327 So. LaSalle St., Chicago, Ill.
Cincinnati	2	June 30, '20	214	L. J. Dunnewold	F. J. Breen, Jr.	3821 Delmar Ave., Cheviot, Ohio
Cleveland	2	Sept. 27, '07	376	C. A. Harrington	D. Ramadanoff	The National Carbon Co., W. 73rd St. & N.Y.C.R.R., Cleveland, Ohio
Columbus	2	Mar. 17, '22	95	S. A. Martin	S. O. Evans	Ohio State University, Columbus, Ohio
Connecticut	1	Apr. 16, '21	333	A. G. Conrad	C. D. Hewitt	227 Church St., New Haven, Conn.
Denver	6	May 18, '15	180	H. B. Palmer	Hubert Sharp	Mountain States Tel. & Tel. Co., P. O. Box 960, Denver, Colo.
East Tennessee	4	Sept. 2, '36	145	R. A. Hopkins	B. H. McCoin	City of Knoxville Electr'c Dept., Knoxville, Tenn.
Erie	2	Jan. 11, '18	65	W. I. Linlor	W. D. Bearce	4121 Sassafras St., Erie, Pa.
Florida	4	Jan. 28, '31	111	J. B. Hiers, Jr.	Joseph Weil	University of Florida, Gainesville, Fla.
Fort Wayne	5	Aug. 14, '08	93	S. D. Summers	W. W. Brooks	General Electric Co., Fort Wayne, Ind.
Georgia	4	Jan. 14, '04	119	J. M. Flanigen	Carl Evans	Electrical South, 1020 Grant Bldg., Atlanta, Ga.
Houston	7	Aug. 7, '28	133	P. H. Underwood	S. C. Commander	2615 Fannin St., Houston, Texas
Iowa	5	June 25, '29	84	L. A. Ware	W. B. Boast	Iowa State College, Ames, Iowa
Ithaca	1	Oct. 15, '02	53	H. G. Smith	E. W. Jones	Cornell University, Franklin Hall, Ithaca, N. Y.
Kansas City	7	Apr. 14, '16	137	C. G. Roush	C. M. Lytle	P. O. Box 679, Kansas City, Mo.
Lehigh Valley	2	Apr. 16, '21	188	E. R. Beers	L. Z. Ludorf	Penn. Power and Light Co., 135 N. Washington St., Wilkes-Barre, Pa.
Los Angeles	8	May 19, '08	540	T. M. Blakeslee	P. L. Johnson	Box 5300, Metropolitan Station, Los Angeles, Calif.
Louisville	4	Oct. 15, '26	73	M. M. Hughes	L. G. Weiser	Westinghouse Electric & Mfg. Co., 1618 Heyburn Bldg., Louisville, Ky.
Lynn	1	Aug. 22, '11	186	J. H. Goss	M. S. Wilson	General Electric Co., Factory 2nd L., West Lynn, Mass.
Madison	5	Jan. 8, '09	73	R. R. Knoll	E. J. Van Duesen	2702 Sommers Ave., Madison Wis.
Mansfield	2	Mar. 6, '39	71	H. O. Whiteley	J. M. Robinson	North Electric Mfg. Co., Galion, Ohio
Maryland	2	Dec. 16, '04	322	H. J. Casey	B. Van Ness	1503 Lexington Bldg., Baltimore, Md.
Memphis	4	May 23, '30	56	J. P. Argo	Herman Leightman	Memphis Light, Gas and Water Div., 179 Madison Ave., Memphis, Tenn.
Mexico	3	June 29, '22	53	J. H. Olmedo	G. Robles	La Consolidada, Apartado 81-Bis., Mexico, D.F. Mexico
Michigan	5	Jan. 13, '11	418	M. B. Stout	J. W. Bishop	134 Englewood Ave , Detroit, Mich.
Milwaukee	5	Feb. 11, '10	313	F. W. Bush	T. B. Jochem	Cutler-Hammer, Inc., 315 N. 12th St., Milwaukee, Wis.
Minnesota	5	Apr. 7, '02	98	Wm. Endicott	C. W. Lethert	Northern States Power Co., 15 So. 5th St., Minneapolis, Minn.
Montana	9	June 24, '31	45	D. K. Brake	C. R. Davis	Montana Power Co., Butte, Montana
Muscle Shoals	4	Feb. 18, '38	33	R. C. Fuller	S. J. Wolfenson	T.V.A., Project W3, Wilson Dam, Ala.
Nebraska	6	Jan. 21, '25	59	J. M. Gibb	I. M. Ellestad	Northwestern Bell Telephone Co., Omaha, Nebr.
New Mexico-West Texas	7	Mar. 7, '40	43	F. A. Decker	L. R. Hammond	Phelps Dodge Corp., El Paso, Texas
New Orleans	4	Dec. 8, '33	133	J. V. Hay	F. E. Johnson	317 Baronne St., New Orleans, La.
New York	3	Dec. 10, '19	3,447	C. C. Whipple	M. D. Hooven	Public Service Electric & Gas Co., 80 Park Pl., Newark, N. J.
Niagara Frontier	1	Feb. 10, '25	198	J. F. Oehler	E. R. Paige	Buffalo Niagara Electric Corp., Buffalo, N. Y.
North Carolina	4	Mar. 21, '29	107	E. E. Kilburn	T. H. Hall	Tide Water Power Co., Wilmington, N. C.
North Texas	7	May 18, '28	170	T. D. Thomas	H. G. Mathewson	Southwestern Bell Telephone Co., Dallas, Texas
Oklahoma City	7	Feb. 16, '22	104	Ralph Randall	R. L. Jones	Southwestern Bell Telephone Co., Oklahoma City, Okla.
Philadelphia	2	Feb. 18, '03	809	G. W. Bower	A. C. Muir	1138 Commercial Trust Bldg., Philadelphia, Pa.
Pittsburgh	2	Oct. 13, '02	662	B. M. Jones	G. W. Penney	Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.
Pittsfield	1	Mar. 25, '04	194	C. W. Germeck	W. S. Fielding	General Electric Co., 100 Woodlawn Ave., Pittsfield, Mass.
Portland	9	May 18, '09	196	C. E. Canada	A. O. Mangold	Northwestern Electric Co., 920 S.W. Sixth Ave., Portland, Ore.
Providence	1	Mar. 12, '20	100	D. W. Alden	G. E. Andrews	40 Bridgham St., Providence, R. I.
Rochester	1	Oct. 9, '14	112	R. A. Whitford	J. H. Rogers	262 Albemarle St., Rochester, N. Y.
St. Louis	7	Jan. 14, '03	361	I. T. Monseth	O. T. Farry	Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.
San Diego	8	Jan. 18, '39	54	B. B. Gravitt	W. J. Kenline	3491 Cooper St., San Diego, Calif.
San Francisco	8	Dec. 23, '04	549	B. L. Robertson	G. C. Tenney	68 Post St., San Francisco, Calif.
Saskatchewan	10	Oct. 14, '25	8	M. L. Haynes	J. R. Young	1945 Scarth St., Regina, Sask, Can.
Schenectady	1	Jan. 26, '03	559	T. M. Linville	P. H. Light	General Electric Co., Central Station Dept., Schenectady, N. Y.
Seattle	9	Jan. 19, '04	230	L. D. Snow	H. M. Gustafson	7003—17th Ave., N.E., Seattle, Wash.
Sharon	2	Dec. 11, '25	153	W. L. Teague	H. S. Gates	1583 McDowell St., Sharon, Pa.
South Bend	5	Feb. 26, '41	58	J. A. Northcott, Jr.	H. E. Ellithorn	417 Parkovash Ave., South Bend, Indiana
South Carolina	4	Mar. 2, '40	53	N. H. Coit	F. W. Chapman	Water & Light Dept., Greenwood, S. C.
South Texas	7	May 23, '30	53	W. F. Pinckert	F. D. Zalmanzig	San Antonio Public Service Co., San Antonio, Texas
Spokane	9	Feb. 14, '13	82	H. J. Reeves	R. C. Kelly	Washington Water Power Co., 825 W. Trent Ave., Spokane, Wash.
Springfield	1	June 29, '22	52	Isaiah Creaser	L. P. Kongsted	American Bosch Corp., Springfield, Mass.
Syracuse	1	Aug. 12, '20	119	S. C. Osborne	M. H. Pratt	Central N. Y. Power Corp., 300 Erie Blvd., W., Syracuse, N. Y.
Toledo	2	June 3, '07	89	C. G. Brennecke	W. M. Campbell	2145 Central Grove Ave., Toledo, Ohio
Toronto	10	Sept. 30, '03	396	D. W. Callander	T. C. D. Churchill	76 Adelaide St., West, Toronto, Ont., Canada
Tulsa	7	Oct. 1, '37	87	O. A. Haas	H. A. Norberg	Nelson Electric Mfg. Co., 219 N. Detroit, Tulsa, Okla.
Urbana	5	Nov. 25, '02	78	M. A. Faucett	W. E. Miller	University of Illinois, Urbana, Ill.
Utah	9	Mar. 9, '17	64	Wm. N. Grooms	J. A. McDonald	General Electric Co., P. O. Box 779, Salt Lake City, Utah
Vancouver	10	Aug. 22, '11	95	T. Ingledow	F. V. Knight	1796 W. 15th Ave., Vancouver, B. C., Can.
Virginia	4	May 19, '22	150	C. L. Crosby	R. M. Bush	Virginia Electric & Power Co., Richmond, Va.
Washington	2	Apr. 9, '03	600	G. R. Wilhelm	F. S. Black	Potomac Electric Power Co., 10th and E Sts., N.W., Washington, D. C.
West Virginia	2	Apr. 9, '40	39	E. D. Knight	R. C. Hoffman	Appalachian Electric Power Co., Charleston, W. Va.
Wichita	7	Sept. 16, '37	57	J. F. Huff	R. F. Dice	Kansas Gas and Electric Co., Wichita, Kans.
Worcester	1	Feb. 18, '20	63	W. W. Locke, Jr.	T. H. Holton	American Steel & Wire Co., Worcester, Mass.
			16,650			
Total Sections	72					

OF CURRENT INTEREST

WPB Announces New Operations Plan; Names New Directors

In accord with its new concentration policy—designed to co-ordinate more effectively our military and economic objectives—the War Production Board has announced the reorganization of its administrative and operational work under new heads.

Two vice-chairmen are provided: William L. Batt, former chairman of the requirements committee, who will serve as general assistant to Chairman Donald M. Nelson and help in determining policies and directing operations; and James S. Knowlson, former director of industry operation, who will determine programs, serve as Mr. Nelson's deputy on the Combined Production and Resources Board, and be chairmen of the requirements committee.

Under the new setup, all the program development work is concentrated under Mr. Knowlson, and all the operational work—including industry and material branches, appropriate bureaus, and field organization—is brought together under Amory Houghton, director general of operations, formerly deputy chief of the bureau of industry branches. Programs and policies governing the flow of materials are worked out under Mr. Knowlson and put into operation through the operating units controlled by Mr. Houghton.

Organization of the office of operations and appointment of his principal aides was announced July 28 by Mr. Houghton. The new appointments are:

C. H. Matthiessen, Jr., former chief of the bureau of priorities, will be assistant director general for operations.

Wade T. Childress, former WPB regional director in Kansas City, will be deputy director general for field operations.

A. I. Henderson, former director of the materials division will be deputydirector general for industry operations.

J. A. Krug, former chief of the power branch, will be deputy director for priorities control.

These top assistants will act as an operations control board to advise the director general on over-all policy.

ALL OPERATING BRANCHES UNDER ONE HEAD

The placing of all of the former industry and commodity branches of the materials and industry operations divisions under Mr. Henderson's immediate direction will bring all the operating branches of the WPB under one head for the first time. Mr. Henderson will also supervise the bureau of governmental requirements, the bureau of construction, the inventory and requisitioning branch which was formerly in the bureau of priorities, and the technical services branch which was formerly in the production division.

The existing industry and commodity branches will continue to be the principal operating units. Plans for regrouping them for administrative purposes are being developed by Mr. Henderson in co-operation with John R. Kimberly and H. W. Dodge, who will be his principal assistants. Former divisional lines will be eliminated, and the work of all industry and materials branches will be co-ordinated in this single organization.

KRUG DIRECTS DISTRIBUTION OF MATERIALS

The direction and administration of priorities becomes the responsibility of Mr. Krug, as deputy director general for priorities control. He will devise and administer new, as well as existing, procedures for the distribution of materials in the war economy. He will be responsible for implementing and enforcing the programs and policies established by Mr. Knowlson, for the distribution of scarce materials to supply military, industrial, and essential civilian demands.

The production requirements plan and other devices for controlling the flow of material will be under the immediate direction of Mr. Krug. He will have as a nucleus for his organization the several branches of the former bureau of priorities except for inventory and requisitioning and the internal operations group.

Mr. Childress, as deputy director general for field operations, will supervise the regional and district offices and other field services, and will work closely with the deputies for priorities control and industry operations to carry forward the policy of reallocating the administration of War Production Board operations announced some time ago by Mr. Nelson.

SOME DIVISIONS REPORT TO HOUGHTON

A number of divisions will for the present report directly to the director general. The division of conservation; the aircraft production division which includes the aircraft, radio, and radar branches of the former production division; the tools division, which was formerly the tools branch; the shipbuilding division, which is the former shipbuilding branch; the facilities staff of the former bureau of industry branches; the division of industry advisory committees; the administrative staffs of the former divisions of production, materials and industry operations; and the internal operations staff of the former bureau of priorities.

It was also announced that the contract distribution branch of the former production division and the bureau of finance of the division of industry operations will be transferred to the Smaller War Plants Corporation.

Synthetic-Rubber Situation Clarified

In response to inquiries about the present status of the program (*EE July '42, p. 883–4*) Rubber Co-ordinator has released a letter to help clarify the situation. Essential substance of this letter follows.

"The Government is building plants based on a program for the production of synthetic rubber as follows:

700,000 Tons per year of Buna S.
60,000 Tons per year of Butyl.
40,000 Tons per year of Neoprene.

"The present program has been fixed at this amount, not because we are still searching for methods or processes but because the amount of raw material required to build plants to use any of the processes is limited and the amount allotted is all that can be spared at this time.

"Buna S, which is a general-purpose rubber, is made by a chemical combination of butadiene and styrene. Butadiene can be made from either alcohol or petroleum and many of the questions regarding the present program arise on account of this fact. Prior to the declaration of war, petroleum was chosen as the base material from which to manufacture synthetic rubber for three reasons: the more advanced experimental development of the process in this country; the substantially lower cost of production; and the apparent lack of demands for war production.

"After the declaration of war, comparative costs were not important. Rubber was essential, and speed was the first consideration. Our principal crude supply was cut off. An increased synthetic program was entered into. This program embraced all available alcohol which could be released from other war needs at that time and as more alcohol became available, because of domestic wartime measures, the proportion of alcohol to be used in the program was increased. 30 per cent of the butadiene included in the present program is being made from alcohol and most of the remainder from petroleum.

". . . . In spite of its ultimate increased cost over petroleum, the alcohol process required less strategic material for the building of new plants—that is, unless it was necessary to build a distillery to get the alcohol. However, a new and better method has been devised in the use of petroleum, and today the amount of strategic material, whether we start with petroleum or alcohol, is practically on an equal basis.

". . . . Today the program is set as we

have outlined. Tomorrow some possible improvement in process or material may appear. If we can use the new, we always will, but we cannot take on the new if to do so would slow up the program. Speed is essential."

PROGRAM EXPANDED

Shortly after Mr. Newhall's letter was issued the War Production Board approved an increase in the synthetic-rubber program from 800,000 tons to 870,000 tons. The increase will be obtained with no expenditure of critical materials for construction purposes, and is possible because of advanced engineering in the production of Butyl rubber. The new techniques permit an increase of 70,000 tons in the formerly planned 60,000-ton capacity of plants already under construction. The expanded program is not expected to alter the projected figure of 300 tons of Butyl rubber to be produced in 1942. Despite the increase, the facts on the rubber situation indicate that there is no rubber to spare for nonessential purposes.

ASA Develops War Standards

Development of standards which will save materials, make fuller use of the nation's production facilities, and make price control more effective by pegging price to quality is expected to be spurred by a contract between the Government and the American Standards Association, War Production Board Chairman Donald M. Nelson and Price Administrator Leon Henderson announced recently. According to the plan, Government funds will provide for the development by the ASA of emergency standards in connection with WPB and OPA wartime supply and price-control measures. The increasing importance of standards for pegging the price of goods to their quality has been pointed out recently in connection with the enforcement of price control. Similarly, the importance of standardization and simplification in connection with the program to concentrate civilian production (see following item) has been emphasized.

QUALITY-CONTROL

The ASA, which has been actively engaged in developing standards for war use since early in the defense program, has developed a series of three standards for quality control in mass production at the request of the War Department. The first two standards, "Guide for Quality Control (Z1.1–1941) and Control Chart Method of Analyzing Data (Z1.2–1941)" were published by the ASA in 1941, in a single pamphlet which is available at a cost of 75 cents per copy. Examples show the application of the control chart to the production of different products and deal with the blowing time of the electrical fuse; the fat content of a woolen yarn (measured as a characteristic of cleanliness); a component part of a piece of electrical apparatus inspected for conformity with four electrical characteristics; and the "spoilage" occurring in the manufacture of a bulk product—pile floor covering.

A third American War Standard recently issued is the "Control Chart Method of Controlling Quality During Production (Z1.3–1942)," selling at 75 cents per copy. This standard is intended to show the manufacturer how he can keep track of his production process by means of a quality-control chart which carries a pair of control limits and which serves as a criterion in determining whether the production process is running smoothly. The control limits are computed from quality measurements made on a number of samples of the product.

MACHINE-TOOL ELECTRICAL STANDARDS

The ASA recently announced the completion of another American War Standard, "Machine Tool Electrical Standards (C74–1942)." The pamphlet is available at 40 cents per copy. The purpose of this standard is to speed the manufacture of machine tools by standardizing the electrical wiring of such tools. It has already been made mandatory by an order of the WPB which limits the future electrification of machine tools to the types of equipment recommended in this standard.

Each of the above American Standards may be obtained direct from ASA, 29 West 39th Street, New York, N. Y.

WPB Orders Concentration of Civilian Industries

Donald M. Nelson announced recently that the War Production Board has approved the principle of concentration of industry as a means of alleviating the strain placed on the civilian economy by the war effort. In approving this principle, the board also approved certain broad policies governing the way in which concentration will be made effective.

SELECTIVE LIMITATION

Heretofore, Mr. Nelson pointed out, the necessary limitation of output of civilian industries has been attained for the most part through orders which impose uniform percentage reductions on all firms. These orders, which could be drafted and applied quickly and were necessary as a first step, have resulted in large savings of critical materials and have facilitated conversion to war production.

The war program has now reached a stage, however, in which the imposition of straight percentage cuts on all firms does not provide for the most effective use of the nation's resources. Consequently, Mr. Nelson said, the board has decided that wherever possible a policy of selective limitation be applied, with essential civilian production concentrated in certain plants and regions.

CONDITIONS FOR CONCENTRATION

In adopting this policy, the board held that there is a strong prima facie case for concentrating the production of civilian goods wherever one or more of the following conditions are found in a civilian industry:

1. Some or all firms in the industry are needed for war production and can be converted to such production.
2. Permitted civilian production is so restricted that economic operation of all firms in the industry is not possible.
3. A significant part of the production is continuing in areas where there are bottlenecks in labor, transport, power, or warehouse facilities.

It is the belief of the board that one or more of these conditions applies to a very large part of civilian industry, and it was agreed that a study should be made at once of the effect upon industry of the curtailment and limitation orders thus far issued.

SMALL PLANTS MAY CONTINUE

No hard-and-fast rules can be laid down, Mr. Nelson said, to govern the selection of "nucleus plants"—plants which will be allowed to continue operation at or near capacity. In general, however, he said, the following criteria will guide WPB officials in such selections:

1. As a rule, small plants will be kept in civilian production, and large plants, which are usually better equipped to handle war contracts, will be required to suspend civilian production.
2. Civilian production should be suspended in areas where labor is urgently needed in war plants.

SEEK TO AVOID POSTWAR MONOPOLY

Mr. Nelson said the board fully realizes that concentration of civilian production raises many difficult problems—compensation to closed-down firms, maintenance of trade marks, and rearrangement of distributive channels. But while these are of great importance to the individual firms involved, he said, from the standpoint of war production they are secondary to the need for determining the degree of curtailment, concentrating production, and converting nonnucleus firms to war work. In working out concentration plans, the board feels that these principles should be applied:

1. Concentration plans should not foster postwar domination of an industry by one or a few companies. A plan which will make possible the re-entry of the largest number of firms into the industry after the war should be given preference, so long as it is consistent with efficient prosecution of the war.
2. Wherever possible, concentration plans should be accompanied by standardization and simplification of the product.
3. Concentration programs should be drafted for limited periods—with one year, probably, as a maximum—and should be flexible enough so that they can be revised if circumstances change.
4. A concentration program for any industry should be co-ordinated with any program which the Office of Price Administration may work out for concentration of the distributive channels of that industry.
5. Where compensation is provided for firms closed down, it should be paid by the firms which continue operations and should be limited to the duration of the concentration program.

Civilian Radio Instructors Needed by Army Air Force

The United States Army Air Force has announced that thousands of civilian radio instructors will be needed to train tens of thousands of enlisted men in the theory and technique of radio operation, according to a report by the Civil Service Commission.

To qualify for a position as radio instructor, an applicant must have either one year of technical radio experience or two years of college study which has included a certain amount of mathematics and physics. Radio men in defense plants will not be considered.

Men chosen for these positions will be given special training. Positions are open for student instructors at $1,620 per year. Upon successful completion of the training course (usually 3 months) student instructors may be promoted to the position of junior instructor at $2,000 per year. Inquiries for further information should be addressed to the Seventh United States Civil Service District, Office of the District Manager, Room 1120, New Post Office Building, Chicago, Ill. Openings are in the states of Illinois, Wisconsin, North Dakota, and Florida.

Educators Consider Relations Between War and Colleges

A conference of officers of institutions and organizations of higher learning was held July 15–16, 1942, at Baltimore, Md., to consider relationships between the war effort and the institutions of higher education—universities, schools of technology, colleges, and junior colleges. During the conference a statement outlining these relationships was drawn up by a working group of approximately 75 officers from various types of institutions, which subsequently was adopted by the conference.

At a similar conference held in Baltimore, January 3–4, 1942 (*EE Jan. '42, p. 171–2*) the institutions of higher education of the country pledged their total resources to the winning of the war and urged prompt development of plans providing for "a continuous and adequate supply of men and women trained in technical and professional skills and in leadership to meet both immediate and long-range needs." The July conference reaffirmed the declarations of the January conference in addition to issuing the foregoing statement, which the American Council on Education has termed "one of the most important pronouncements which have been made by representatives of higher education during this war." Full text of the statement follows:

"1. We deplore the continuing lack of any adequate, co-ordinated plan for the most effective utilization of higher education toward the winning of the war, and we urge the establishment of such a co-ordinated plan at the earliest possible moment.

"2. The government is not utilizing the institutions of higher education to capacity and is, therefore, impeding the flow of highly trained manpower essential to victory in a long war.

"3. Through the provision of year-round instruction and many other recently adopted changes, higher education has demonstrated its readiness to devote all its facilities and energies to the war effort. However, the lack of any adequate, co-ordinated plan has given rise to widespread confusion among governmental agencies, educators, students, and the general public. This confusion constitutes a serious barrier to the full wartime utilization of higher education and hence to the successful prosecution of the war.

"4. We believe that the full utilization of higher education is essential to the winning of a long total war because:

"*a.* The war can be won only if a continuous flow of highly trained manpower is prepared for participation in the war effort.

"*b.* The institutions of higher education are the only institutions staffed and equipped to provide many essential types of advanced training.

"5. To insure more effective utilization of the facilities of higher education through the establishment of a co-ordinated plan, we recommend to the Secretary of War, the Secretary of the Navy, the Director of Selective Service System, and the chairman of the War Manpower Commission that immediate steps be taken to assure effective and continuing co-operation between the agencies they represent and higher education.

"6. Among the premises upon which such a co-ordinated plan should be based are the following:

"*a.* The function of higher education is to provide the nation with broadly educated and highly trained men and women. This permanent function must be continuously performed lest the health, safety, and welfare of the nation be endangered; but in the present grave crisis, the winning of the war must have right of way in higher education as well as in all other national undertakings.

"*b.* To develop breadth of understanding, stamina, and qualities of leadership is a major function of higher education. These are essential characteristics of good officers in the armed forces. It is significant that although only 12 per cent of the men already inducted into Selective Service have had college training, 80 per cent of the men selected for officer training in the Army have been chosen from this group of college men.

"*c.* The year-round instruction which has been established by colleges and universities to serve the war effort creates new financial problems for students. Present plans for the voluntary enlistment and training of college students provide only for those young men who can finance a college education or who can secure assistance within existing financial-aid programs. Large numbers of qualified young men are therefore barred from special types of training. Such a situation limits the supply of broadly educated officer material and denies to many young men equal opportunity for training. Economic status, race, or creed should not be allowed to restrict the training of adequate, skilled manpower at the college level for the war program.

"*d.* Present plans for the enlistment and training of college students are inadequate also because (1) they fail to provide clearly defined avenues of training and service for those male students who are physically unqualified for military service but who are intellectually fitted to contribute to the winning of the war through industrial and other civilian pursuits, and (2) they fail to include women, who, as shown in other countries, have a vital part to play in the national effort.

"*e.* The institutions of higher education stand ready to make such further adaptations of their programs and facilities as may be necessary to meet the objectives set up by the Federal agencies concerned with the training of college students for war service.

"7. The proposed co-ordinated wartime plan for higher education should be established at once so that with the opening of the fall terms in 1942 the institutions of higher education of the country can throw their entire resources into the war effort.

"8. We recommend that the American Council on Education, which was established during the First World War to represent all the organizations of higher education, be recognized as the appropriate nongovernmental agency to take such steps as may be necessary to implement the proposals herein stated and to serve in a continuous capacity for facilitating co-operation between higher education and government."

Additional Information on Army Specialist Corps

As supplementary material to the talk on the Army Specialist Corps by Brigadier General William O. Hotchkiss, reported in the August issue of *Electrical Engineering*, pages 440–2, the following information may be of interest.

Appointments to the Army Specialist Corps will be made for the duration of the War and six months thereafter. Appointments for a lesser period may be made under exceptional circumstances at the discretion of the Director General. There will be two classes of personnel, officers and specialists, who will have relative rank with officers and enlisted men of the Army. In general, their titles will be the same as those for corresponding rank in the Army. Promotions may be made by the Director General. Decorations authorized by law may be awarded by the Secretary of War upon the recommendation of the Director General. The Army Specialist Corps uniform will be practically the same as that of the officers and enlisted men, respectively, of the Army. Both uniform and insignia will be distinctive so that members of the corps will be readily recognized as such.

The rate of pay for members of the corps is based upon the Civil Service Classification Act and will, in general, be comparable to that in use for similar grades in the Army. Any person occupying a Government position other than temporary may be transferred or appointed to the corps and shall during the period of employment therein be deemed to be on leave of absence without pay. Individuals appointed to the Corps will not acquire Civil Service status, but all appointments for the duration are subject to the Civil Service retirement deductions.

Members of the corps will exercise administrative and supervisory functions only. They will not exercise command functions in so far as Army officers or enlisted men are concerned, except that when Army personnel are assigned to duty in any activity operated by officers of the Corps, they will be subject to the orders of the officers to the same extent and in the same manner as though they were members of the Corps.

Selective Service Broadens Technical-Student Deferments

Emphasizing the necessity of maintaining the potential supply of men in scientific and specialized fields through continuing their education in college and their employment in the fields for which they have been selected for deferment, Occupational Bulletin No. 10, issued recently by Selective Service, is considered by the American Council on Education to be one of the most important yet published dealing with students.

The bulletin includes consideration for occupational deferment of selected graduate students and provides for a 60-day period for deferment beyond graduation. It specifies the following fields in which shortages of personnel exist: accounting; chemistry; economics; aeronautical engineering; automotive engineering; chemical engineering; civil engineering; electrical engineering; heating, ventilating, refrigerating, and air-conditioning engineering; marine engineering; mechanical engineering; mining and metallurgical engineering; radio engineering; safety engineering; air, highway, railroad, and water transportation engineering; geophysics; industrial management; mathematics; meteorology; naval architecture; personnel administration; physics; astronomy; psychology; and statistics.

As changes in personnel needs modify the fields in which there are shortages, this list probably will be revised. The inclusion of some of the more general fields will require even more careful appraisal of the students' ability and vocational purpose in order to select those for whom the college will request occupational classification.

A graduate or postgraduate student who is pursuing additional studies for these scientific and specialized fields, may be considered for occupational classification if he is also engaged as a graduate assistant in the instruction of undergraduate students in these fields, or if he is engaged in scientific research related to the war effort which is supervised by a recognized Federal agency.

Holders of degrees in these fields, continuing the deferment already granted them as necessary men to complete their training, will be deferred for an additional 60 days beyond graduation, in order that they gain time to be placed among the skilled personnel in their essential activity.

Priority System Described. A pamphlet called "How the New Priority System Works" has recently been issued by the Research Institute of America, analyzing the revised governmental production-requirements plan. Directed to the attention of business executives so that they may learn how to present a clear and convincing picture of their inventory, requirements, production schedule, priority pattern, and importance in the war picture, the analysis aims at an effective understanding and prosecution of the war program. Copies may be obtained at a price of $2 from the Research Institute of America, 292 Madison Avenue, New York, N. Y.

New Radio Series Announced by Publishers

A new series of technical books in the field of radio communication engineering, to be prepared under the consulting editorship of Beverly Dudley, acting managing editor of *Electronics* has been announced by the McGraw-Hill Book Company of New York, N. Y. To be known as the Radio Communication Series, these forthcoming books are intended to provide a co-ordinated and uniform group of texts of collegiate caliber covering all phases of modern radio communication, to serve the student of communication engineering as well as to serve as reference material for the practicing engineer. With the present military interest in and need for trained men in the field of radio communication, the launching of this new series comes at a propitious time. As originally outlined, the series calls for individual texts on:

1. Basic Mathematics for Communication Engineers
2. Principles of Electricity
3. Introduction to Radio Engineering*
4. Fundamentals of Electric Circuits
5. Electrical Filters
6. Transmission Lines and Wave Guides*
7. Antennas and Radiation Phenomena
8. Electron Tubes in Communication
9. Frequency Modulation*
10. Ultrahigh Frequency Technique
11. Acoustics and Electromechanical Devices
12. Communication Measurements

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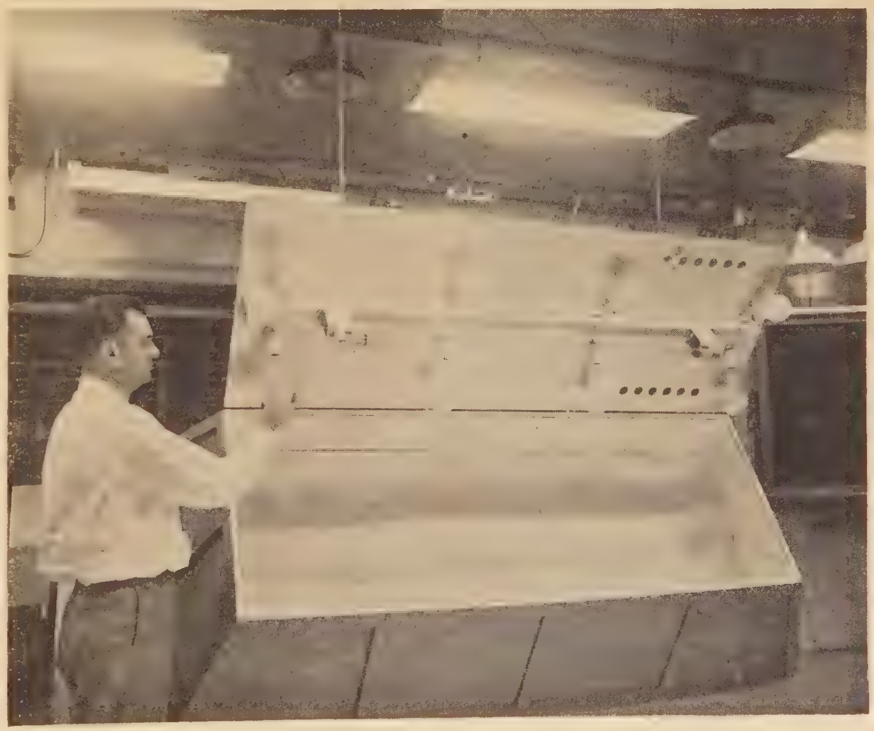
* These books are already in preparation.

Women Fill Technical Positions

To replace male engineers lost to the company through selective service or enlistment in the armed forces, the General Electric Company is hiring 150 young college women in a technical status. The first 22 of the group are now at work, and this number will be supplemented each week until the quota is reached. The girls are being given the company's well-known test engineering course, and in the fall will take classroom courses in the fundamentals of engineering and company organization. The work the girls are now doing is considered elementary, and they are shifted from department to department in an orientation course. Work they will do includes figuring computations, charting graphs, and calibrating fine instruments for use in the machine-tool industry.

Applicants selected for the course must have majored in either mathematics or

"Jumbo Luminaires" Provide Diffused Light



Designed to provide diffused lighting, especially for war plants working with polished metal sheets which tend to reflect glare, this light fixture was developed in the lamp department of the General Electric Company, Cleveland, Ohio. It contains a 3,000-watt mercury tube, which is shown between eight 200-watt inside-frosted filament lamps, and produces approximately 150,000 lumens. The unit, measuring eight feet in length by four feet in width is constructed of fiberboard, thus saving critical metal commonly used in industrial fixtures.

physics in college and have had minor training in the other. Their mathematical training must include courses through calculus.

Engineers Now Being Hired by U. S. Employment Service

The War Manpower Commission has requested firms doing war work to hire all their engineers and other executives through the United States Employment Service. Positions available will be filled from the National Roster of Scientific and Specialized Personnel, to which names are constantly being added, including those obtained from Selective Service occupational questionnaires. Engineers who consider themselves available for war jobs are urged to see that their names and records are on the roster.

According to Richard C. Brockway, director of USES for New York State, the New York professional office has filled more than 150 positions paying $3,000 a year or more during one recent month—including positions as structural engineers, controller for a chemical construction company, an architectural designer, industrial engineers, and personnel executives.

Airplane Engines Produce Power During Break-in Tests

New airplane engines which once did no useful work during break-in runs have now been harnessed to produce electric power during the testing period. The new power-producing method has been achieved by connecting the airplane engines to ordinary generators of the type long used in Diesel-electric power plants, which "feed back" into the plant electric-supply system.

Airplanes, unlike automobiles, may not be broken in by slow driving, but must be ready to run at full speed on the initial take-off, which requires more power than actual flying. During the 12 hours usually required to break in an airplane engine, great quantities of high-octane gasoline are consumed—gasoline which under the old method, utilizing a propeller as the load, was dissipated in churning the air. The new process feeds back about 2,000 kilowatt-hours during the test run of one large engine.

The engine being tested is connected by a flexible-shaft coupling to a magnetic coupling, which transmits power to a synchronous generator. In operation, this unit, working as a synchronous motor, is brought up to speed, and the coupling is energized just enough to crank the engine slowly. When the engine fires, the coupling is de-energized, and the motor cut off the line. After the engine is brought up to speed, the coupling can again be energized. The synchronous machine then operates as a current-absorption-type dynamometer, generating power which is fed back into the line.

Recently, however, a more flexible power-recovery system eliminating the coupling device has been developed. This system incorporates the characteristics of the coupling and the constant-speed generator in one variable-speed unit.

End-Product Designations to Aid Critical Materials Allocation

As the supply of basic materials for the war program and related civilian economy is not large enough to satisfy all essential requirements, it is necessary to review the most essential requirements of finished products and determine their urgency of manufacture. To this end, a standard method of identification and reporting has been established by the War Production Board for all industry.

The method of identification consists of a dual system of letters and numbers, letters indicating broad classes of ultimate purchasers and numbers indicating the classes and subclasses into which certain industries have been grouped. Effective August 31, 1942, all orders for critical materials must carry such identification. Neither the code number nor letter indicates the order of importance, but merely serves to indicate the purpose for which any particular product or material will be used. The system thus will aid in the effective scheduling of the flow of materials in our war program.

As an example, a manufacturer of typewriters for use by the Army would designate orders for raw materials with the code identification *A*-19.00; if for the Navy, *N*-19.00; and if for other use, *X*-19.00. (*A*, *N*, and *X* designate use of the end-product by the Army, Navy, and others, respectively, and 19.00 is the code number for manufacturers of equipment and supplies for office use.) Full details of the system and how to apply it are covered in a booklet "Priorities Regulation No. 10" which can be obtained from the War Production Board, Division of Industry Operations, Washington, D. C.

New WPB Power Branch Head. Herbert S. Marks, assistant general counsel of the War Production Board, has been appointed acting director of the WPB Power Branch, filling the vacancy caused by the appointment of J. A. Krug, former chief of the Power Branch, as deputy director general for Priorities Control. Mr. Marks continues as assistant general counsel of WPB, which office he has held since April 1941, and advances from the office in which he served since the creation of the Branch in July 1941. He came to the Office of Production Management, predecessor of WPB, from the staff of the Trustees of the Associated Gas and Electric Corporation. Earlier he was general counsel of the Bonneville Power Administration and assistant general counsel of the Tennessee Valley Authority. He is a native of Danville, Pa., and a graduate of the University of Pennsylvania and of the Harvard Law School.

War Plants Urged to Use Production-Drive Aids

The war-production drive inaugurated last March by Donald M. Nelson, chairman of the War Production Board called upon labor and management to form joint committees to aid manufacturers in meeting the vast production requirements for the war effort. The WPB reports that production is approaching goals set by the president six months ago as a direct consequence of the co-operation of labor and management plus the service rendered by the War Production Drive Headquarters which is a WPB agency. However, a survey has disclosed that there are still a large number of plants in which these labor-management committees have not reported to the War Production Drive Headquarters and which consequently are not receiving the production aids and services made available by the WPB. Other plants, it is believed, have not yet established production drives.

Among the material and services supplied to all labor-management committees in war-production plants are the following:

Stickers
Posters
Streamers
Booklets and leaflets for information stands
Motion pictures
Transcription service for plants with loud speakers
Bulletin board placard service
Material for plant newspapers
Information exchange reporting the progress of the drive
Awards
Booklets of plans for production drives

Labor-management committees not receiving the above aids and those interested in organizing war-production drives are invited to communicate at once with the War Production Drive Headquarters, War Production Board, Washington, D. C.

OTHER SOCIETIES •

National Safety Executive Named; Program Expanded

N. H. Dearborn, dean of the division of general education of New York (N. Y.) University, has been appointed executive vice-president and managing director of the National Safety Council. He will actively direct the greatly expanded wartime program, which is being conducted by the Council and which is intended to cover every phase of accident prevention. (*EE, Oct., '41, p. 510–11; Apr. '42, p. 221–2.*)

Funds necessary for this enlarged program, which aims to stop accidents which are impeding war production and delaying victory, are being obtained now from commerce and industry by the Council's War Production Fund to Conserve Manpower. Local safety councils will be given assistance by direct allocation of funds needed to amplify their present programs and by additional personnel for industrial and public safety. It is planned to establish local safety councils in war production areas where none now exist, in recognition of added safety hazards caused by the migration and concentration of population in these areas. It is further planned to aid plant management in strengthening plant safety programs so that safety precautions will be impressed upon the worker as a necessity in the plant, in the home, and in every activity.

IES Announces New Officers

The Illuminating Engineering Society recently announced new officers for 1942–43 as follows:

President: R. B. Brown, Jr., illuminating engineer, Boston (Mass.) Edison Company

Vice-President (term ending September 30, 1944): S. B. Williams (M'37) editor, *Electrical World*, New York, N. Y.

General secretary: O. P. Cleaver (A'36) head of the illumination section, commercial engineering department, Westinghouse Lamp Division, Bloomfield, N. J.

Treasurer: A. F. Wakefield, F. W. Wakefield Brass Company, Vermilion, Ohio

Directors (term ending September 30, 1944): A. A. Brainerd, Philadelphia (Pa.) Electric Company; R. W. Staud, Benjamin Electric Manufacturing Company, Des Plaines, Ill.

Regional vice-presidents (term ending September 30, 1944): I. L. Illin G. Wisconsin Electric Power Company, Milwaukee, representing the mid-western region; G. R. Baumgartner, General Electric Company, Nela Park, Cleveland, Ohio, representing the Great Lakes region; Fred J. Wellhouse, Westinghouse Electric and Manufacturing Company, San Francisco, Calif., representing the Pacific Coast region; Clarence C. Keller, Holophane Company, Inc., New York, N. Y., representing the northeastern region; and J. M. Guillory, industrial and commercial engineering division, New Orleans (La.) Public Service, Inc., representing the southern region.

Future Meetings of Other Societies

American Institute of Chemical Engineers. 35th annual meeting, November 16–18, 1942, Cincinnati, Ohio.

American Institute of Mining and Metallurgical Engineers. Regional meeting, October 12–17, 1942, Los Angeles, Calif.; joint meeting, coal division, AIME, and fuel division, ASME, October 1–2, 1942, St. Louis, Mo.

American Physical Society. 251st meeting, November 27–28, 1942, Chicago, Ill.

American Society of Mechanical Engineers. Fall meeting, October 12–14, 1942, Rochester, N. Y.; annual meeting, November 30–December 4, 1942, New York, N. Y.

American Society of Tool Engineers. Semiannual meeting, October 16–17, 1942, Springfield, Mass.

American Welding Society. 23d annual meeting, October 12–15, 1942, Detroit, Mich.

Association of Iron and Steel Engineers. Annual convention, September 22–24, 1942, Pittsburgh, Pa.

Electrochemical Society. Fall meeting, October 7–10, 1942, Detroit, Mich.

Illuminating Engineering Society. Annual convention, September 21–22, 1942, St. Louis, Mo.

National Electrical Manufacturers Association. Annual meeting, October 26–30, 1942, New York, N. Y.

National Safety Council. 31st national safety congress and exposition, October 27–29, 1942, Chicago, Ill.

INDUSTRY.....

More Generating Units for Government Plants

More than a million kilowatts of hydroelectric power will be added to the nation's supply by July 1944 at five Bureau of Reclamation multipurpose irrigation projects in the West, according to a recent announcement, as a result of higher priorities granted recently by the War Production Board for Reclamation dams, powerhouses, and generating equipment. The additions will bring the total operating capacity of Reclamation power plants in 12 states to $2^1/_2$ million kilowatts. The potential annual output will be more than 20 billion kilowatt-hours.

The highest priorities assigned—*AA*-3—were allotted to the following installations:

Four generators, 30,000 kw each, at Parker Dam. The first generator was scheduled to go into action in August, the second in September, the third in October, and the fourth in May 1943.

Two 75,000-kw generators at Grand Coulee Dam, scheduled to start operating in November this year. These two machines were originally ordered for Shasta Dam but were shifted to make their output available to war industry a year sooner.

An 82,500-kw generator (*A*-5) at Boulder Dam, in December.

The following units were assigned *AA*-4 ratings:

Green Mountain Dam, Colorado Big-Thompson project, Colorado—providing 21,600 kw (two generators of 10,800-kw capacity) in February and March 1943.

Grand Coulee Dam, Washington—three generators of 108,000 kw each (*L*-4, 5, and 6), scheduled for July, September, and November 1943, bringing the total capacity of the Grand Coulee plant to 818,000 kw—second only to Boulder Dam in size.

Boulder Dam, Arizona-Nevada—generators *N*-7, capacity 82,500 kw, scheduled for December 1943 (bringing the total installed capacity at this largest power plant in the world to 1,032,000 kw).

Shasta and Keswick Dams, Central Valley projects, Calif.—two big generators of 75,000 kw each at Shasta by January 1944 and another in March; two generators of 25,000 kw each at Keswick in May and June 1944.

October 4–10 Designated Fire Prevention Week

With the issuance of a proclamation by President Roosevelt, designating the week of October 4 to 10, 1942, as Fire Prevention Week, plans are being made for bringing about the widest and most effective observance of the event this year since President Woodrow Wilson in 1920 issued the first Fire Prevention Week proclamation. President Roosevelt, in his proclamation, called upon the people of the United States to give special heed to the importance of taking active measures to conserve human and material resources from fire. At the same time, he directed the Office of Civilian Defense and other Federal units to initiate programs for stressing the importance of attaining the objectives sought in the fire-prevention effort. State and local governments and other agencies also were asked to promote observance.

In 1941 the national fire loss amounted to $304,000,000 and for the first six months of this year the loss approached $171,000,000 or four per cent greater than the comparable period in 1941. Every year fire takes a toll of 10,000 lives throughout the United States and a very much larger number of people are injured by fire. In the first six months of 1942 there were 38 large fires in the United States, each involving an estimated loss of $250,000 or more, many of which were in war-production plants or in essential wartime facilities such as warehouses, ships, and piers. But in some cases even small fires occurring in plants under subcontract, making some essential part for large airplanes or other implements of war, have held up assembly lines of large war-production factories.

In this critical year, when every fire diverts material and manpower from decisive war production, interrupts and impedes the war program, and in many cases destroys vital materials and facilities that cannot be replaced during the present emergency, it is especially important that all public and private organizations join together in an intensive effort to eliminate fire hazards and to take essential steps for fire protection.

Photographic Exposure Computer. Photographic exposures for all types of negative films in land, marine, and aerial photography, for any location in the world and for a wide variety of light conditions can be determined from the photographic exposure computer issued recently by the American Standards Association. Designated "American Emergency Standard" (*Z*38.2.2–1942), the computer originally was prepared for use by the photographic divisions of the armed services. The present edition is identical with the original, except for lighter weight binding and the stock on which it is printed. The computer is pocket size ($3^1/_4$ by 5 inches) and contains 24 pages printed on lightweight durable cardboard. It includes light index tables for various latitudes, scene index tables for different types of scenes under various light conditions, and a simple exposure calculator which gives the final result—all supplemented by appropriate explanatory material. An appendix covers exposures under unusual conditions and exposures with the use of photoflash and photoflood lamps. The computer may be obtained at a cost of $1 from ASA, 29 West 39th Street, New York, N. Y.

1942 National Power Show. The 15th National Exposition of Power and Mechanical Engineering scheduled for Grand Central Palace, November 30 to December 5, 1942, is being planned this year as a direct aid to war production. The exhibits should be of interest to engineers and operating men who are faced with many new production and maintenance problems, as well as to men with many industrial responsibilities. The displays will include insulation, combustion controls, engineering supplies, electrical equipment, power transmission and material handling products, and a complete line of tools for various production and maintenance uses.

EDUCATION • • •

Federal Loans to Aid Students in Technical Courses

A loan fund of $5,000,000 has been voted by Congress and will soon be available to help college students speed up their training for technical and professional jobs. Monthly loans totalling not more than $500 a year, at $2^{1}/_{2}$ per cent interest annually, and cancelled if the student is drafted during training, will be made directly to students by colleges and universities, and by public or college-connected agencies. Federal funds will be allocated to the loaning institutions by the United States Office of Education on the submission of estimates of the amount of money for such loans.

This financial assistance will permit students to pursue intensive programs of study which will prepare them as soon as possible to meet the growing need for technicians. Loans are available only to students whose technical or professional education can be completed within two years, in the fields of engineering, physics, chemistry, medicine (including veterinary), dentistry, and pharmacy.

The student agrees in writing: (1) to participate, until otherwise directed by the chairman of the War Manpower Commission, in accelerated programs of study in any of the authorized fields; and (2) to engage for the duration of the wars in which the United States is now engaged, in such employment or service as may be assigned by officers or agencies designated by the chairman of the commission.

The maintenance of satisfactory standards of scholarship and the actual need of assistance will be added factors in determining the eligibility of the students to be awarded the loans, and these loans will be evidenced by notes executed by student borrowers payable to the Treasurer of the United States.

Science Series Planned. A series of books on science to be issued under the title, "Treasury of Science," and to be edited by a board including professors in scientific fields, is planned for publication by the L. B. Fischer Publishing Corporation, New York, N. Y. The series is to consist of a number of pocket-size books, selling at $1.25, and is designed to serve as a source of introductory information on various aspects of modern scientific knowledge for students and the general public. AIEE members are invited by the publishers to submit manuscripts on scientific subjects, which should be sent direct to the publishing company.

Expansion of Facilities at Cooper Union. The completion of new facilities for laboratory instruction in communication subjects of the day and evening courses at Cooper Union was announced recently by Norman L. Towle (A'20, M'24), head of the department of electrical engineering. Day and evening curricula in electrical engineering now include subjects in power or communication specialization, available to the student on an option basis. Instructional procedures have been developed and revised to standards commensurate with optional specialization at a senior level, and the recently acquired communication equipment will extend the range of fundamental electrical measurements that may be made to frequencies above the television band. The new apparatus, includes an impedance bridge, a 9-inch oscilloscope, standard, square-wave, and video-signal generators, oscillators, and a wave analyzer.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers, publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Writing a Technical Paper

To the Editor:

The initial start in the preparation of either a paper or an address is something to say. Substance rates higher than form, with men whose professional lives depend on results, and accurately stated fact stands ahead of empty polished English. Although adequate presentation is essential, mastery of English will not take the place of facts worth telling. Attempts to bolster mediocre investigations with long-winded reports bring to mind Lincoln's comment on one of McClellan's reports. The President, who wanted results, replaced the fluent general.

The first requirement of clear writing is clear thinking. A fountain cannot rise higher than its source, and neither can mud-puddle thinking produce spring-water writing. All too frequently, getting a clear style will require a potential author to revise if not indeed to recast his methods of thought as well as his sentences.

The prime requirement for logical writing is logical thinking. The way some authors wander through their writings suggests a dim path in dense woods, the kind of path that before long disappears altogether. With a few persons, a faulty Mendelian inheritance or perhaps an unsuspected birth injury is the cause. A competent editor may be the only help that such unfortunates can have. Yet, as a rule, meandering of this type comes from mental inertia, which means that meandering authors can correct their defect any time that they become willing to make the necessary effort.

Writing logically includes paying proper attention to perspective. Obtaining perspective in writing requires a comprehensive knowledge of the subject and also a willingness to write for the audience instead of for the author. A mass of minute detail and excessive attention to some one phase may satisfy the author's vanity or personal interest, yet such presentation never gives the audience the balanced ration that normal persons want.

"Brevity is the soul of wit," and conciseness in an article intended for mature minds is a virtue. A reviewer thinks that my present not-inconsiderable paring of this 1,900-word letter is enough. He may be wrong, because such a question must remain a matter of judgment, yet even a virtue can be overdone. The person who reads a paper is doing the author a favor, and the author should take account of that fact. A brevity too great for ease in reading is no better than excessive length.

For some centuries a man was not considered learned unless he wrote in Latin. In the days when good modern-language dictionaries had not yet been born, this attitude was perhaps excusable, despite its source. One of the chief hangovers remaining from this old notion is the circumlocution of the third person passive, which ponderous, pompous, and other unskilled authors affect. Although the passive, like strychnine, has legitimate use, too much of the stuff turns it from a tonic to a poison. To be consistent, a good engineer, who is a man of action, should write in the active voice. If every engineer did so, perhaps we should hear less often the comment, "They say what they don't mean, and mean what they don't say." Life is short; need I list the other professions that call forth the same comment?

Years ago a certain one-horse college looked down on a tiny farmers' center that consisted chiefly of a single unshaded street, which formed an inexhaustible source of dust in the summer and of mud in the winter. A new instructor at the college, wanting a patch or two on his shoes, could see no way to get the pair to the town cobbler other than to float them himself down the town's river of dust. Torn woefully by the horns of need and desire, the fledgling called on the college president to ask if it would be in keeping with the dignity of an instructor in that great university to be seen on Main Street carrying a pair of worn shoes. Today, thanks in large measure to that president, who did not take himself too seriously, the former rural collegette has become a university of some standing. The reply of this president met the situation: "Young man, if you have only a little dignity, you had best take good care of what you have." Many a stilted, obscurely worded paper has reminded me of this story. A fully qualified writer of good taste never has to worry about dignity.

Inadequate preparation is a fault all too common. One remedy is to make an outline of the points the article should cover, checking their order carefully, and then to tell the story to a boy in his middle 'teens. Unless such a story deals with highly abstract matter, if the boy cannot understand it, then there is something wrong with both the material and its telling. If a second and a third attempt, each time with a new boy and additional preparation, do not bring better results, write out a draft, let it sleep for a time, and then start all over.

The best critic of my own writings, a cultured gentleman, was so well qualified that he never felt obliged to remind me that he had an advanced degree and a position of authority. Because he was as honest as a piece of plate glass I was always able to evaluate his comments for my audiences. Equipped with courage rather than conceit, he never feared to tell me that he did not understand something, and to suggest that I clarify. Such a critic, as rare as a precious jewel, is worth hogsheadsful of flattering wives and friends, and boatloads of bluffers. Nevertheless, a critic who finds fault for the sake of finding fault is hardly better than a back-patter.

Woolley and Scott's "College Handbook of Composition," among other virtues, has the somewhat unusual merit of keeping to its subject; it actually practices what it preaches. Yet my experience has been that any such book, in the hands of a beginning author, leads the author to spend time and effort in quibbling over inconsequential matters and in arguing—"argufying" is really a more appropriate word here—over sentences that an experienced author would recast instead of defending. Rather than such a manual, despite its value to both a student and a seasoned author, I recommend close study of a carefully edited nontechnical journal, such as *Newsweek* or *Time.*

When a diamond cutter has done his job properly, a polisher can easily finish the gem. In the same way, if an article is roughhewn correctly, a qualified editor will finish the work in a short time. Yet even the best editor cannot put enough polish on a piece of shale to make it worth carrying away; the author must supply diamonds if he wishes the editor to bring out a diamond finish.

Omnipotence in every field of human endeavor is reserved for Hitler alone, not for a mere editor. Perspiration will never taken the place of inspiration; yet inspiration without perspiration rarely gets results of value. For these reasons an author should himself expect to do a fair part of the total work required to produce a good manuscript, not leaving too much for even the most willing and qualified editor.

My Anglo-Saxon vocabulary, with its short, simple words, must have come from my boyhood reading and rereading of Sir Walter Scott and others like him. Each of three modern languages has been of value to me in my study of English. On my second attempt I succeeded in breaking the preservative ice around Latin enough to start dissecting the cadaver. The chief gain for myself is the knowledge that Spanish is live Latin, and the opinion that Spanish, when taught logically, has a far higher value for most Americans than dead Latin. Seneca, for example, was a Spaniard; educated Spaniards took over the Roman senate when Rome had gone far toward decay. Perhaps Spain's help also was too little and too late.

A lifelong reading of good writings has given me my knowledge of what good writing is; Hawthorne, Kipling, Poe, Stevenson, and Tennyson are examples of my favorite authors. Henty and his stereotyped hack work, unknown today, showed me many things to avoid. My practice in writing began with letter writing, and continued with laborious correction of draft after draft of formal work. Without going into details, let me say that whatever command of English I may have has come from efforts that had little or nothing to do with classroom work. What I have done in self-instruction others can do also.

This little article is a summary. For such an abstract, a comparatively large proportion of short paragraphs is permissible. In general, however, a short paragraph should be reserved to relieve long paragraphs, or for force. An attempt to obtain either force or clarity by a series of paragraphs of only one or two sentences means that the author does not think connectedly, and the result is a choppiness and lack of organization that grates on a lover of good English. "An equal emphasis on all is no emphasis at all." Paragraph an article by topics, not with a ruler. Use a ruler merely to make sure that no paragraph is overly long. A sufficiently liberal use of headings will help to point out the progression that a reliable author wishes to make in every article, yet nothing will take the place of proper paragraphing. Only good paragraphing allows unity and cohesion.

Choppy sentences are as bad as choppy paragraphs. Although necessary in a story for small children, they prevent subordination of detail, so that reading a string of them is like riding over cobblestones or washboarding. Longer sentences, with subordinate parts for subordinate matters, present a clearer and more faithful picture; they permit perspective. Sentences make paragraphs, and paragraphs make an article—or break it.

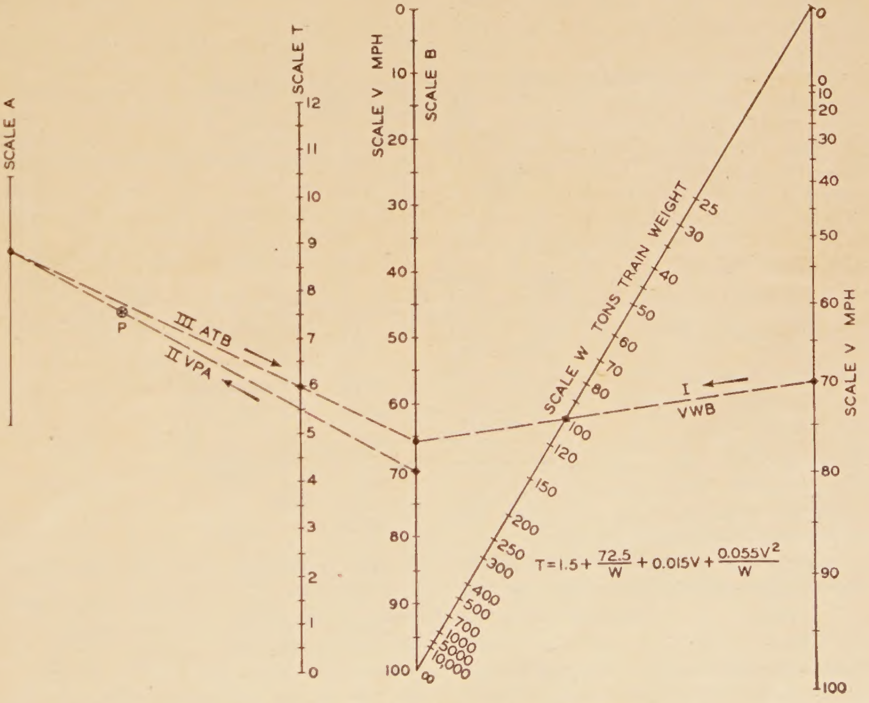
HENRY HENDRICKS KETCHAM (M'23)

Editor, International Correspondence Schools,
Scranton, Pa.)

Electric Locomotive Application

To the Editor:

Herewith the writer's train resistance nomographical chart of the formula on page 1211 of AIEE *Transactions,* volume 60, 1941, in the paper entitled "Electric Locomotive Application" by E. W. Brandenstein and D. R. MacLeod (pages 1210–15). Drawn upon the chart in dashed lines is a numerical example, graphically computed: To find the train resistance T in pounds per ton for a train of 100 tons (W) at 70 miles per hour (V), draw computing secant I from 70 on



Nomographical chart of train resistance

(right-hand) scale *V*, through 100 on scale *W*, continuing it to intersect scale *B*. Draw secant II from 70 on scale *V* (middle) through common point *P*, continuing it to intersect scale *A*. From this intersection draw secant III to the intersection of I on *B*. Where secant III cuts scale *T*, at 6, is the required value of the train resistance, which satisfies the equation shown on the chart. Thus by drawing only three lines across the scales of this compact nomogram the equation is graphically evaluated. *T* increases with the speed and decreases with the weight of the train. Turning scale *B* coincides with scale *V*. Turning scales *A* and *B* are not graduated. The point *P* is an isolated point on a scale through which *all* secants II pass.

Arrows show direction in which the secants are to be drawn; Roman numerals, the order in which they are drawn; and the letters, the three scales through which each secant passes.

CARL P. NACHOD (A'07)

Vice-president, Nachod and United States Signal Company, Louisville, Ky.)

Air Raid Alarm Device

To the Editor:

Under the rules as laid down by the United States Army in Signal Circular 8-2 it is necessary that stations on certain frequencies monitor a designated key or key-relay broadcast station, in order to receive the 30-second 1,000-cycle warning tone, and abide by the instructions which follow. It was found to be necessary to assign three men to monitoring duty in order to cover the 24 hours of each day.

To eliminate this useless waste of manpower, a device was developed, by the use of which the receiver is absolutely silent until a 1,000-cycle tone is sent out for a period of ten seconds. This then turns on the speaker automatically with a terrific blast, which eliminates any possibility of failure to receive the alarm through failure of the human element, thus giving a definite audible alarm.

We used an ordinary receiver capable of high audio output and inserted a filter between the grid of the output tube and ground which attenuated all but 1,000 cycles. When the first relay *RL*1 is not energized its back contact provides power to a second high resistance relay *RL*2 which will remain energized for about ten seconds because it is crossed by a large capacitor *C*2. When an extended note of 1,000 cycles is received, the armature of the first relay *RL*1 does not return to its back contact to recharge *C*2, causing the second relay *RL*2 to trip out, which energizes a third relay *RL*3, the contacts of which connect the speaker into the circuit and remove the filter *X*1, *C*1. Thus an audible alarm is given and the receiver operates normally until the device is reset by the push button *PB*. The receiver used was a General Electric model *K*-63.

The filter *X*1–*C*1 offers a high impedance to frequencies from 900 to 1,100 cycles with its peak at 1,000 cycles. All other frequencies are bypassed to ground through contact "*A*" of *RL*3. Transformer *T*2 is connected with its low impedance toward the output transformer *T*1 of the set, its output being connected to the coil of *RL*1 through Rectox unit *RX*.

With the switch *S*1 in the alarm position, push button *PB* is closed momentarily to charge *C*2, thus closing contact "*B*" of *RL*2. This switch also closes the primary of *T*2 to ground. The output of the receiver, after attenuation of certain frequencies by *X*1–*C*1, flows through *T*2 and is applied to the coil of *RL*1. The voltage at this point normally ranges from one to three volts. During periods of about 1,000 cycles the voltage across *RL*1 rises to about five volts, opening contact "*A*" of *RL*1, thus removing the charging source of *C*2.

While *C*2 is charged, or during periods when contact "*A*" of *RL*1 is closed, the armature of *RL*2 is up, closing contact "*B*" of *RL*2 thus forming holding circuit for *RL*2. Should an extended frequency near 1,000 cycles occur (ten seconds) contact "*A*" of *RL*1 is held open and the charge in *C*2 leaks off through *R*2 and *RL*2. When the armature of *RL*2 falls back against its contact "*A*", relay *RL*3, is energized, thus opening its contact "*A*" and removing the filter *X*1–*C*1 from the circuit. At the same time, contact "*B*" of *RL*3 is closed connecting the speaker back into the circuit, giving an audible alarm.

By placing the switch *S*1 in the nonalarm position the receiver is made to operate normally, having *RL*3 energized through contact "*A*" of *RL*2, placing the speaker in the circuit, and removing filter *X*1–*C*1.

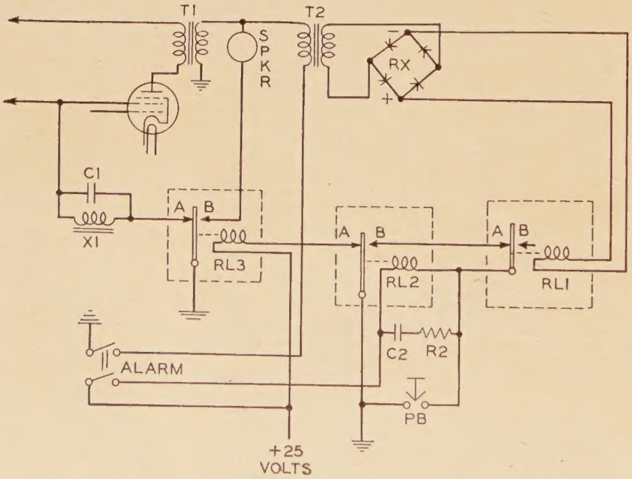
About 25 volts for operation of *RL*2 and *RL*3 is taken from the "*B*" plus of the receiver through a resistance.

Note: We would have used a lower resistance for *RL*1 if we could have purchased one.

Take steps to maintain proper bias on output tube (resistor or bias cells), otherwise the life of this tube will be much less than normal.

LIEUTENANT ARTHUR H. VICKERSON,
SERGEANT ROBERT L. GRAY

(Police Department, Boston, Mass.)



Air raid alarm device

(*Patent rights reserved*)

*T*1—*Output transformer of set*

*T*2—*United Transformer Company type S14 transformer (not critical—use any plate to five-ohm voice-coil transformer)*

RX—*Copper-oxide rectifier*

*X*1—*United Transformer Company 39019 choke*

*C*1—*0.025 microfarad*

*RL*1—*"Sigma" 2,000-ohm relay (use any relay that will operate on three to four volts direct current)*

*RL*2—*"Sigma" 5,000-ohm relay*

*C*2—*240 microfarads*

*R*2—*5,000 ohms*

(Values of RL2, C2, R2 determine the time element of the device. Any relay of high resistance is suitable)

*RL*3—*Struthers-Dunn CXB-51 relay (type not critical)*

PB—*Push button*

*S*1—*Double-pole toggle switch*

Man-Hours or Efficiency for Increased War Effort

To the Editor:

Our greatest progress in the furtherance of our present war effort is not going to be by building more plant but by using more efficiently the plant we have. The greatest error we have made so far is that we think of production in terms of man-hours rather than in terms of what that man in that hour can do.

When we begin to increase the efficiency of our present operations it will be a very simple thing to double our present production with the same number of man-hours. We can, inside of another few months, double that again if the efficient methods which the industrial geniuses know can be applied and are enthusiastically followed.

As an example of this, in the present building of ships $^1/_8$-inch and $^5/_{32}$-inch electrodes are largely being used for welding. If these should be changed to $^3/_{16}$-inch, and $^1/_4$-inch, the speed of welding would be more than doubled. The cost of the electrode also would be reduced, the production of electrode by the same number of man-hours would be increased, and the reliability of the joint would be increased.

The great problem we have is not more welders, more shipyards, and more men but more efficiency with what we now have. Man-hours alone will never beat the Axis, as we are seeing. The efficiency possible by the application of industrial genius will.

J. F. LINCOLN (F'39)

(President, Lincoln Electric Company, Cleveland, Ohio)

Evaluating Determinants

To the Editor:

In the 1941 AIEE *Transactions* (pages 1235–41) appeared "A Short Method for Evaluating Determinants and Solving Systems of Linear Equations With Real or Complex Coefficients," by Prescott D. Crout. Although this use is not explicitly mentioned, the procedure outlined may be used as a very systematic and general form of "network reduction." In particular, it may be used to obtain the impedance of any given network when viewed from any given pair of terminals. Investigation will show that the mathematical steps involved in setting up the "auxiliary matrix" are equivalent to automatically making various delta to wye transformations in the circuit.

Crout's method has the advantage that the entire network may be considered at once, mutual impedances between the various elements being considered at all times, and the reduction to the equivalent impedance effected through a very systematic procedure which, by carrying a check column, offers a check on accuracy after every reduction.

Suppose that the impedance of the network shown in Figure 1 as viewed from the terminals, is desired. The procedure is:

1. Draw in the necessary number of mesh currents, taking as one of the mesh currents, the current that would flow through the terminals if they were short-circuited.

2. Write the impedance matrix for the network, using as the last row and column, the mesh which includes the terminals.

3. Calculate the auxiliary matrix by the method explained by Crout. The last diagonal term thus calculated will be the impedance of the network as viewed from the terminals.

4. The "distribution factors" giving the other currents as a per unit of the terminal current are then readily obtained by calculating the final matrix.

5. A check column may be appended if it is desired to check the accuracy of every reduction in calculating the auxiliary Z.

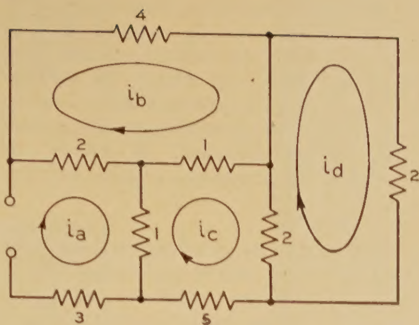


Figure 1. Simple resistance network

For the network shown in Figure 1,

$$Z = \begin{array}{c|cccc|c} & d & c & b & a & ch \\ \hline d & 4.0000 & -2.0000 & 0.0000 & 0.0000 & 2.0000 \\ c & -2.0000 & 9.0000 & -1.0000 & -1.0000 & 5.0000 \\ b & 0.0000 & -1.0000 & 7.0000 & -2.0000 & 4.0000 \\ a & 0.0000 & -1.0000 & -2.0000 & 6.0000 & 3.0000 \end{array}$$

$$\text{Aux } (Z) = \begin{array}{c|cccc|c} d & 4.0000 & -0.5000 & 0.0000 & 0.0000 & 0.5000 \\ c & -2.0000 & 8.0000 & -0.1250 & -0.1250 & 0.7500 \\ b & 0.0000 & -1.0000 & 6.8750 & -0.3091 & 0.6909 \\ a & 0.0000 & -1.0000 & -2.1250 & 5.2182 & 1.0000 \end{array}$$

$$\text{Dist } (I) = \begin{array}{cccc} d & c & b & a \\ \hline 0.0818 & 0.1636 & 0.3091 & 1.0000 \end{array}$$

where, for example, Dist $(i_c) = -(1.0000) \times (-0.1250) - (0.3091)(-0.125) = 0.1636$.

The equivalent resistance of the network as viewed from the terminals is therefore 5.2182 ohms, and the distribution factors are also immediately obtained.

Further modifications of the method may be given. For instance, if the original matrix had been arranged with the *c* row as the last row, then the last diagonal term in the auxiliary matrix would have been the transfer impedance between the *a* and *c* meshes (or, more correctly, the reciprocal of the transfer admittance between the *a* and *c* meshes). This same quantity could, of course, be obtained from the present example simply by dividing the equivalent resistance between terminals by the distribution factor of the i_c mesh current.

W. H. HUGGINS (Enrolled Student)

(Oregon State College, Corvallis)

Criteria for Neutral Stability of Transformer Circuits

To the Editor:

The paper by Messrs. Shott and Peterson, "Criteria for Neutral Stability of Wye-Grounded-Primary Broken-Delta-Secondary Transformer Circuits" (AIEE *Transactions*, volume 60, 1941, November section, pages 997–1002), gives comprehensive treatment to a subject which for years has been difficult in theory and elusive in practice. The following may be of interest since it describes a related trouble not dealt with in the paper.

The difficulty occured on a distribution system in which grounds on 5,000-volt 60-cycle three-phase circuits are indicated by installations of potential transformers solidly tied to the busses.

It was found necessary to protect these transformers against burnouts resulting from accidental crossups with d-c circuits, specifically trolley wires (600 volts) and series arclight loops (about 6,000 volts). This was done by installing blocking capacitors between neutrals and ground. It was then found that grounds on the distribution circuits sometimes set up dangerous oscillations between capacitor and transformers. It appeared to be 60-cycle series resonance, and consideration of the transformers' saturation characteristic showed that it might occur in a range of capacitances from about 0.1 to 1.0$^+$ microfarads.

This hypothesis was checked by experiment. Voltages of about 10,000 were observed, and currents through the potential transformer primaries were more than 100 times normal: enough to cause failure in less than half an hour. Resistance loading of the secondaries failed to remedy the situation, but insertion of 2,500-ohm resistors in series with the capacitors appears to have been completely effective. Sensitivity of ground indication is not impaired.

JEROME J. TAYLOR (A'40)

(Electrical engineer, The Detroit Edison Company, Detroit, Mich.)

NEW BOOKS • • •

Handbook of Civilian Protection. Edited by L. L. Snyder, R. B. Morris, and others. McGraw-Hill Book Company, Whittlesey House, New York, 1942. 184 pages, illustrations, etc., 7$^1/_2$ by 5 inches, fabrikoid, $1.25.

Intended to provide the basic information which the general public should have concerning protection in air attacks. Air-raid conduct and services, fire fighting, incendiary bombs, poison gas, first aid, civilian conservation and salvage, and war-time nutrition are discussed. There is also a bibliography.

Practical Construction of Warships. By R. N. Newton. Longmans, Green and Company, London, New York, and Toronto, 1941. 318 pages, illustrations, etc., 10 by 6$^1/_2$ inches, cloth, $6.

This textbook, based on courses at the Royal Naval Engineering College and the Royal Naval Dockyard, deals with the principles of construction and erection of the structure, and the more important ships' services of modern warships. Chapters on launching, docking and undocking, and on the prevention of corrosion are included.

Short Course in Tensor Analysis for Electrical Engineers. By G. Kron John Wiley and Sons, New York; Chapman and Hall, London, 1942. 250 pages, diagrams, etc., $9\frac{1}{2}$ by 6 inches, cloth, $4.50.

Contains a series of lectures delivered to students in the advanced course in engineering of the General Electric Company. It provides a short outline of the tensorial method of attack of certain problems in electrical engineering and shows its application to those confronting the power engineer.

Illumination Engineering. By W. B. Boast. McGraw-Hill Book Company, New York and London, 1942. 274 pages, diagrams, etc., $9\frac{1}{2}$ by 6 inches, cloth, $3.

The purpose of this text is to give electrical engineering students the fundamental concepts of illumination, their historical background and interrelationships. Present electrical sources of light are discussed in addition to the design and testing of illumination systems. A list of recommended standards for commercial, industrial, and public interior illumination is included.

How to Read Electrical Blueprints. By G. M. Heine and C. H. Dunlap. American Technical Society, Chicago, Ill., 1942. Illustrations, etc., $8\frac{1}{2}$ by $5\frac{1}{2}$ inches, cloth, $3.

The symbols used to represent the various pieces of electrical equipment as indicated on blueprints are discussed and separate sections deal with house wiring and automobile wiring as well as with motor and generator diagrams.

Electric Motors in Industry. By D. R. Shoults and C. J. Rife, edited by T. C. Johnson. John Wiley and Sons, New York; Chapman and Hall, London, 1942. 389 pages, illustrations, etc., $9\frac{1}{2}$ by 6 inches, cloth, $4.

Written for the industrial engineer, this book presents information on the characteristics and control of electric motors which is intended to aid in the efficient selection and installation of the proper equipment. Description of the mechanical construction of motors is given to aid in understanding their operation, and a discussion of the principles and applications of electronic devices is included, but no attempt has been made to cover the generation, transmission, or distribution of power.

Electromechanical Transducers and Wave Filters. By W. P. Mason. D. Van Nostrand Company, New York, 1942. 333 pages, diagrams, etc., $9\frac{1}{2}$ by 6 inches, cloth, $5.

Aims to set forth the fundamental analogies and interconnections between electrical theory and mechanical theory. Electrical network theory is analyzed and applied to lumped mechanical systems; acoustic equations and the vibration of membranes and plates are dealt with; and the form and design of electromechanical elements and systems are discussed.

Introduction to Electrochemistry. By S. Glasstone. D. Van Nostrand Company, New York, 1942. 557 pages, diagrams, etc., $9\frac{1}{2}$ by 6 inches, cloth, $5.

Aims to provide an introduction to electrochemistry in its present state of development. The activity concept, the interionic attraction theory, the proton-transfer theory of acids and bases, and the consideration of electrode reactions as rate processes are discussed. A chapter on electrokinetic phenomena is also included.

ASTM Standards on Electrical Insulating Materials. By ASTM committee D-9 on electrical insulating materials. American Society for Testing Materials, Philadelphia, Pa., December 1941. 448 pages, illustrations, etc., 9 by 6 inches, paper, $2.25.

Contains specifications and test methods in their latest form as well as the current report of the committee on electrical insulating materials. The report outlines the committee's work and gives proposed revisions of standards. Several appendixes discuss the significance of various tests.

The "Particles" of Modern Physics. By J. D. Stranathan. Blakiston Company, Philadelphia, Pa., 1942. 571 pages, illustrations, etc., $9\frac{1}{2}$ by 6 inches, fabrikoid, $4.

Presents the material considered essential to an appreciation of modern physics and the newer concepts of atomic structure. The experimental evidence upon which each concept is founded is stressed throughout. The book is intended both as a fundamental text in its field and as a reference work for advanced students. A number of specific references have been included as footnotes.

Procedure Handbook of Arc Welding Design and Practice. 7th Edition. The Lincoln Electric Company, Cleveland, Ohio, 1942. 1,308 pages, 6 by 9 inches, illustrations, etc., simulated leather, $1.50.

An explanation of the methods and techniques used in welding, this manual aims to present the most recent information on welding symbols, new allowable stresses, pre-heating for welding, stress relieving, speeds and costs, tubular construction, weldability of aluminum alloys, general metallurgical characteristics of metals and alloys, and appearance and styling of welded design. Typical applications of arc welding are given detailed emphasis.

Welding Handbook. Edited by W. Spraragen. American Welding Society, New York, 1942. 1,593 pages, illustrations, cloth, $6.

Intended to present up-to-date information on welding for use as a textbook and reference manual in engineering and trade schools. The book aims at covering the physics and metallurgy of welding and the weldability of steels; welding and allied processes; materials used; training, inspection, and safety; design considerations and testing of welding; and the applications of welding.

Training Manual for Auxiliary Firemen. Edited by Horatio Bond, W. Fred Heisler, R. J. Douglas. National Fire Protection Association, Boston, Mass., 1942. 416 pages, diagrams, etc., $7\frac{5}{8}$ by $5\frac{1}{4}$ inches, paper, $1.50.

A textbook intended for the instruction of newly recruited auxiliary firemen. It covers courses on civilian defense, control of incendiaries, gas masks for war gases, and primary and secondary courses in fire fighting and control. Supplementary material is included for advanced training.

Handbook of Mechanical Design. By G. F. Nordenholt, J. Kerr, and J. Sasso. McGraw-Hill Book Company, New York and London, 1942. 277 pages, diagrams, etc., 11 by $8\frac{1}{2}$ inches, cloth, $4.

Presents practical methods and procedures which have been in use in engineering designing departments. Chapters cover charts and tables for general arithmetical calculations; the properties of materials; beams and structures; latches, locks, and fastenings; springs; power transmission elements and mechanisms; drives and controls; and design data on production methods. The information is chiefly presented as charts, nomograms and tables, and in drawings.

PAMPHLETS • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Definitions of Welding Terms and Master Chart of Welding Processes. American Welding Society, New York, 1942. 31 pages, 40 cents.

Standard Methods for Mechanical Testing of Welds. American Welding Society, New York, 1942. 25 pages, 40 cents.

National Emergency Steels. American Society for Metals, Cleveland, Ohio, 1942. 35 pages, 25 cents.

Depreciation of Group Properties (Bulletin 155). By Robley Winfrey. Iowa State College, Ames, Iowa, 1942. 131 pages, no charge.

Plastics From Agricultural Materials (Bulletin 154). By O. R. Sweeney and L. K. Arnold. Iowa State College, Ames, Iowa, 1942. 52 pages, no charge.

Standards on Radio Wave Propagation: Measuring Methods (supplement to the *Proceedings* of the Institute of Radio Engineers, volume 30, No. 7, Part II). IRE, New York, 1942. 16 pages, 50 cents.

Standards on Radio Wave Propagation: Definition of Terms (supplement to the *Proceedings* of the Institute of Radio Engineers, volume 30, No. 7, Part III). IRE, New York, 1942. 8 pages, 20 cents.

Standards on Facsimile (supplement to the *Proceedings* of the Institute of Radio Engineers, volume 30, No. 7, Part IV). IRE, New York, 1942. 5 pages, 20 cents.